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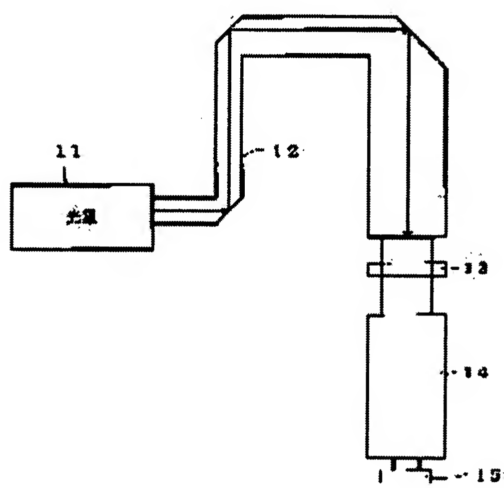
(54) METHOD FOR INSPECTING OPTICAL SYSTEM, METHOD FOR MANUFACTURING THE SAME, AND METHOD FOR MANUFACTURING ALIGNER

(57)Abstract:
PROBLEM TO BE SOLVED: To perform adjustment and evaluation so that environmental conditions where a device is installed and used can be mode available by inspecting the optical performance of an optical system using inspection light with a wavelength which is adjusted by a wavelength adjustment process.
SOLUTION: The light from a light source 11 is applied to a test mask 13 through a lighting optical system 12, and the test pattern of the test mask 13 is transferred to a photosensitive substrate 15 via a projection optical system 14. Then, by observing or measuring the test pattern image transferred onto the photosensitive substrate 15 using such an observation device as an electron microscope, the optical performance of the projection optical system 14 can be evaluated, thus easily and similarly creating the same environment as that at the location where the optical system is installed or used under an environment where the optical performance of the optical system is adjusted and inspected, even if environmental conditions differ between the location, where the optical system is adjusted and inspected and where the optical system is installed or used.



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CLAIMS

[Claim(s)]
[Claim 1] The inspection method of optical system characterized by providing the following. The wavelength-adjustment process which adjusts the wavelength of the inspection light for inspecting the optical-character ability of the aforementioned optical system based on the difference between the 1st environmental condition by which the optical-character ability of optical system is inspected, and the 2nd environmental condition for which the aforementioned optical system is used. The inspection process which inspects the optical-character ability of the aforementioned optical system using inspection light with the wavelength adjusted according to the aforementioned wavelength-adjustment process.
[Claim 2] The manufacture method of optical system characterized by providing the following. The 1st inspection process which inspects the optical-character ability of optical system under the 1st environmental condition using the 1st inspection light with the 1st wave. The amount calculation process of adjustments which computes the amount of adjustments about the aforementioned optical system so that the optical-character ability of the aforementioned optical system may become the optimal under the 2nd environmental condition for which the aforementioned optical system is used. The optical adjustment process of adjusting the aforementioned optical system based on the amount of adjustments about the aforementioned optical system obtained at the aforementioned amount calculation process of adjustments. The 2nd inspection process which inspects the optical-character ability of the aforementioned optical system adjusted according to the aforementioned optical adjustment process under the 1st environmental condition of the above using the 2nd inspection light with the 2nd different predetermined wave from the inspection light of the 1st aforementioned wave.
[Claim 3] The manufacture method of optical system characterized by providing the following. The amount calculation process of adjustments which computes the amount of adjustments about the aforementioned optical system based on the difference between the 1st environmental condition by which the optical-character ability of optical system is inspected, and the 2nd environmental condition for which the aforementioned optical system is used so that the optical-character ability of the aforementioned optical system may become the optimal under the 2nd environmental condition. The optical adjustment process of adjusting the aforementioned optical system based on the amount of adjustments about the aforementioned optical system obtained at the aforementioned amount calculation process of adjustments. The inspection process which inspects the optical property of the aforementioned optical system adjusted according to the aforementioned optical adjustment process using a checking light with the wavelength adjusted according to the aforementioned wavelength-adjustment process in the wavelength-adjustment process which adjusts the wavelength of a checking light for inspecting the optical-character ability of the aforementioned optical system under the 1st environmental condition of the above.
[Claim 4] The aforementioned wavelength-adjustment process is the manufacture method of the optical system according to claim 3 characterized by including the wavelength calculation process of asking for the wavelength of the checking aforementioned light based on the difference between the 1st

environmental condition and the 2nd environmental condition of the above.
[Claim 5] The aforementioned optical system is the manufacture method of the optical system according to claim 3 or 4 characterized by being the projection optical system which projects the image of the predetermined pattern formed on a mask on a photosensitive substrate.
[Claim 6] The manufacture method of optical system characterized by providing the following. The 1st adjustment process which adjusts optical system under the 1st environmental condition. The 1st inspection process which inspects the optical-character ability of the aforementioned optical system adjusted according to the aforementioned 1st adjustment process under the 1st environmental condition of the above using inspection light with predetermined wavelength. The amount calculation process of adjustments which computes the amount of adjustments about the aforementioned optical system based on the difference between the 1st environmental condition by which the aforementioned 1st adjustment process and the 1st inspection process of the above are performed, and the 2nd environmental condition for which the aforementioned optical system is used so that the optical-character ability of the aforementioned optical system may become the optimal under the 2nd environmental condition of the above. The 2nd adjustment process which adjusts the aforementioned optical system based on the amount of adjustments about the aforementioned optical system obtained at the aforementioned amount calculation process of adjustments, the wavelength-adjustment process which adjust the wavelength of the aforementioned inspection light, and the 2nd inspection process which recheck under the 1st environmental condition of the above in the optical property of the aforementioned optical system adjusted according to the aforementioned 2nd adjustment process using the inspection light adjusted according to the aforementioned wavelength-adjustment process.
[Claim 7] The aforementioned wavelength-adjustment process is the manufacture method of the optical system according to claim 6 characterized by including the wavelength calculation process of asking for the wavelength of the inspection light for rechecking the optical-character ability of the aforementioned optical system, based on the difference between the 1st environmental condition of the above, and the 2nd environmental condition of the above.
[Claim 8] The aforementioned optical system is the manufacture method of the optical system according to claim 6 or 7 characterized by being the projection optical system which projects the image of the predetermined pattern formed on a mask on a photosensitive substrate.
[Claim 9] The exposure method characterized by providing the following. The process which offers the optical system manufactured by the manufacture method of optical system according to claim 8. The mask setting process of setting the aforementioned mask as the body side of the aforementioned optical system. The substrate setting process of setting the aforementioned photosensitive substrate as the image surface of the aforementioned optical system. The lighting process which illuminates the aforementioned mask, using light with the same wavelength as the inspection light used by the inspection light or the 1st inspection process of the above used by the 1st inspection process of the above as a light for exposure, and the projection process which projects the pattern image of the aforementioned mask on the aforementioned photosensitive substrate through the aforementioned projection optical system.
[Claim 10] The manufacture method of the aligner equipped with the light source which outputs light with predetermined criteria wavelength in order to illuminate the mask with which the predetermined pattern characterized by providing the following was formed, and the projection optical system which projects the image of the pattern of the aforementioned mask on a photosensitive substrate. The amount calculation process of adjustments which computes the amount of adjustments about the aforementioned projection optical system based on the difference between the 1st environmental condition by which the aforementioned aligner is manufactured, and the 2nd environmental condition for which the aforementioned aligner is used so that the optical-character ability of the aforementioned projection optical system may become the optimal under the 2nd environmental condition. The optical adjustment process of adjusting the aforementioned projection optical system based on the amount of adjustments about the aforementioned projection optical system obtained at the aforementioned amount calculation process of adjustments. The wavelength-adjustment process which adjusts the criteria wavelength of the

light outputted from the aforementioned light source to the wavelength of a checking different light from this criteria wavelength. The inspection process which inspects the optical property of the aforementioned projection optical system adjusted according to the aforementioned adjustment process using a checking light with the wavelength adjusted according to the aforementioned wavelength-adjustment process under the 1st environmental condition of the above.

[Claim 11] The aforementioned wavelength-adjustment process is the manufacture method of the aligner according to claim 10 characterized by including the wavelength calculation process of asking for the wavelength of a checking light for inspecting the optical-character ability of the aforementioned projection optical system, based on the difference between the 1st environmental condition of the above, and the 2nd environmental condition of the above.

[Claim 12] The manufacture method of the aligner equipped with the light source which outputs light with predetermined criteria wavelength in order to illuminate the mask with which the predetermined pattern characterized by providing the following was formed, and the projection optical system which projects the image of the pattern of the aforementioned mask on a photosensitive substrate. The 1st adjustment process which adjusts the aforementioned projection optical system under the 1st environmental condition. The 1st inspection process inspected under the 1st environmental condition of the above using light with the aforementioned criteria wavelength outputted from the aforementioned light source in the optical-character ability of the aforementioned projection optical system adjusted according to the aforementioned 1st adjustment process. The amount calculation process of adjustments which computes the amount of adjustments about the aforementioned projection optical system based on the difference between the 1st environmental condition by which the aforementioned 1st adjustment process and the 1st inspection process of the above are performed, and the 2nd environmental condition for which the aforementioned aligner is used so that the optical-character ability of the aforementioned projection optical system may become the optimal under the 2nd environmental condition. The 2nd adjustment process which adjusts the aforementioned projection optical system based on the amount of adjustments about the aforementioned projection optical system obtained at the aforementioned amount calculation process of adjustments, The wavelength-adjustment process which adjusts the criteria wavelength of the light outputted from the aforementioned light source to the wavelength of the light of the 2nd checking, The 2nd inspection process which inspects the optical property of the aforementioned projection optical system adjusted according to the 2 aforementioned adjustment processes using the aforementioned light with the wavelength adjusted according to the aforementioned wavelength-adjustment process of the 2nd checking under the 1st environmental condition of the above.

[Claim 13] The aforementioned wavelength-adjustment process is the manufacture method of the aligner according to claim 12 characterized by including the wavelength calculation process of asking for the wavelength of the aforementioned light of the 2nd checking for rechecking the optical-character ability of the aforementioned projection optical system, based on the difference between the 1st environmental condition of the above, and the 2nd environmental condition of the above.

[Claim 14] The manufacture method of an aligner given in any 1 term of the claim 10 characterized by having further the criteria wavelength setting process of setting the wavelength of the light which will be outputted from the aforementioned light source by the time it is installed in the basis of the 2nd environmental condition of the above for which the aforementioned aligner is used as the aforementioned criteria wavelength, or a claim 13.

[Claim 15] The exposure method characterized by including the process which offers the aligner manufactured by the manufacture method of an aligner according to claim 14, the lighting process which illuminates the aforementioned mask with the criteria wavelength from the aforementioned light source, and the projection process which projects the pattern image of the aforementioned mask on the aforementioned photosensitive substrate through the aforementioned projection optical system.

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* NOTICES *

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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the evaluation method of the projection optical system in the aligner which manufactures a semiconductor device and a liquid crystal display element according to an optical lithography process preferably especially about the evaluation method of optical system.
[0002]
[Description of the Prior Art] In order to manufacture elements, such as a semiconductor device and a liquid crystal display element, the aligner which carries out projection exposure of the mask as the projection original edition with which the predetermined pattern was formed on a photosensitive substrate through a projection optical system is used. The reflective refraction type projection optical system constituted combining lenses, such as a refracted type projection optical system which consists of lenses which have a penetrable optical property to the light of exposure wavelength as a projection optical system of such an aligner, such as an optical element of refractility, or an optical element of refractility, and the mirror as an optical element of reflection nature is used.
[0003] On the other hand, in recent years, the degree of integration of the element represented by a semiconductor device, the liquid crystal display element, etc. increases, and detailed-izing also of the pattern imprinted on a photosensitive substrate is being enhanced. And in order to realize the aligner for manufacturing various kinds of elements including the aligner which can imprint the pattern of a mask good to a photosensitive substrate, and a semiconductor device with a further more high degree of integration, the very high optical-character ability which has higher resolution in the projection optical system in an aligner is required.
[0004] In order to attain higher resolution, it is beginning to be used from the conventional extra-high pressure mercury lamp to which the light source which supplies exposure light also emits light in g line (436nm) or i line (365nm) as soon as the numerical aperture (NA) of a projection optical system is large in an excimer laser with more short wavelength etc. The place which these aligners are installed and is actually used is not necessarily the same as the environmental condition to which adjustment and evaluation of the projection optical system of an aligner were carried out. For example, compared with the altitude to which adjustment and evaluation of the projection optical system of an aligner were performed, far, the place which an aligner is installed and is actually used has the high altitude, and turns into a low place of average atmospheric pressure in many cases.
[0005]
[Problem(s) to be Solved by the Invention] Generally the atmospheric pressure from which the altitude changes changes, and the refractive index of air changes in connection with it. And if the refractive index of air changes, in the optical element of refractility, such as a lens, etc., the angle of refraction of the beam of light in a refracting interface will change, consequently the image formation performance of optical system will change.
[0006] In the former, when the altitude (it is hereafter called lowlands.) which performs adjustment of

the projection optical system of an aligner and evaluation differs from the altitude (it is hereafter called high ground.) for which an aligner is actually installed and used, in lowlands, a projection optical system is once made into a desired image formation performance by adjustment etc. Then, the lens interval of a projection optical system is changed, for example, and in the state where the aligner was moved and installed in high ground, the image formation performance of a projection optical system is intentionally changed so that the image formation performance of a request of a projection optical system can be reproduced.

[0007] However, when the aberration offset for different altitude in a projection optical system is added, the image formation performance of a projection optical system gets worse, and exact evaluation of the image formation performance of a projection optical system becomes difficult in lowlands. For this reason, in order for an aligner to check beforehand the optical-character ability of the projection optical system in the place actually installed and used in lowlands, a large-scale facility and large-scale time, such as an atmospheric pressure adjustable game par which can contain the whole aligner, are needed.

[0008] Then, this invention aims at offering the manufacture method of the inspection method of optical system that the image-formation performance of optical system, such as a projection optical system, can be adjusted and estimated that equipment becomes the same as the environmental condition installed and used also under a different environmental condition from the environmental condition for which it is made in view of the above technical problem, and optical equipments, such as an aligner, are actually installed and used, the optical system using the inspection method, and an aligner.

[0009]

[The means for solving invention] In order to attain the above purpose, in invention concerning a claim 1 The wavelength-adjustment process which adjusts the wavelength of the inspection light for inspecting the optical-character ability of the aforementioned optical system based on the difference between the 1st environmental condition by which the optical-character ability of optical system is inspected, and the 2nd environmental condition for which the aforementioned optical system is used, The inspection method of optical system of having the inspection process which inspects the optical-character ability of the aforementioned optical system using inspection light with the wavelength adjusted according to the aforementioned wavelength-adjustment process is offered.

[0010] The 1st inspection process which inspects the optical-character ability of optical system under the 1st environmental condition in invention concerning a claim 2 using the 1st inspection light with the 1st wave, The amount calculation process of adjustments which computes the amount of adjustments about the aforementioned optical system so that the optical-character ability of the aforementioned optical system may become the optimal under the 2nd environmental condition for which the aforementioned optical system is used, The optical adjustment process of adjusting the aforementioned optical system based on the amount of adjustments about the aforementioned optical system obtained at the aforementioned amount calculation process of adjustments, The manufacture method of optical system of having the 2nd inspection process which inspects the optical-character ability of the aforementioned optical system adjusted according to the aforementioned optical adjustment process under the 1st environmental condition of the above is offered using the 2nd inspection light with the 2nd different predetermined wave from the inspection light of the 1st aforementioned wave.

[0011] In invention concerning a claim 3, it is based on the difference between the 1st environmental condition by which the optical-character ability of optical system is inspected, and the 2nd environmental condition for which the aforementioned optical system is used. The amount calculation process of adjustments which computes the amount of adjustments about the aforementioned optical system so that the optical-character ability of the aforementioned optical system may become the optimal under the 2nd environmental condition, The optical adjustment process of adjusting the aforementioned optical system based on the amount of adjustments about the aforementioned optical system obtained at the aforementioned amount calculation process of adjustments, The wavelength-adjustment process which adjusts the wavelength of a checking light for inspecting the optical-character ability of the aforementioned optical system The manufacture method of optical system of having the inspection process which inspects the optical property of the aforementioned optical system adjusted

according to the aforementioned optical adjustment process using a checking light with the wavelength adjusted according to the aforementioned wavelength-adjustment process under the 1st environmental condition of the above is offered.
[0012] In invention concerning a claim 4, the aforementioned wavelength-adjustment process offers the manufacture method of optical system including the wavelength calculation process of asking for the wavelength of the checking aforementioned light based on the difference between the 1st environmental condition and the 2nd environmental condition of the above, based on invention of the above-mentioned claim 3. In invention concerning a claim 5, the manufacture method of the optical system which is a projection optical system which projects the image of the predetermined pattern with which the aforementioned optical system is formed on a mask on a photosensitive substrate is offered based on invention of the above-mentioned claim 3 and a claim 4.
[0013] The 1st adjustment process which adjusts optical system under the 1st environmental condition in invention concerning a claim 6, The 1st inspection process which inspects the optical-character ability of the aforementioned optical system adjusted according to the aforementioned 1st adjustment process under the 1st environmental condition of the above using inspection light with predetermined wavelength, It is based on the difference between the 1st environmental condition by which the aforementioned 1st adjustment process and the 1st inspection process of the above are performed, and the 2nd environmental condition for which the aforementioned optical system is used. The amount calculation process of adjustments which computes the amount of adjustments about the aforementioned optical system so that the optical-character ability of the aforementioned optical system may become the optimal under the 2nd environmental condition of the above, The 2nd adjustment process which adjusts the aforementioned optical system based on the amount of adjustments about the aforementioned optical system obtained at the aforementioned amount calculation process of adjustments, The manufacture method of optical system of having the wavelength-adjustment process which adjusts the wavelength of the aforementioned inspection light, and the 2nd inspection process which rechecks the optical property of the aforementioned optical system adjusted according to the aforementioned 2nd adjustment process using the inspection light adjusted according to the aforementioned wavelength-adjustment process under the 1st environmental condition of the above is offered.
[0014] In invention concerning a claim 7, the aforementioned wavelength-adjustment process offers the manufacture method of optical system including the wavelength calculation process of asking for the wavelength of the inspection light for rechecking the optical-character ability of the aforementioned optical system, based on the difference between the 1st environmental condition of the above, and the 2nd environmental condition of the above based on invention of a claim 6. In invention concerning a claim 8, the aforementioned optical system offers the manufacture method of the optical system which is a projection optical system which projects the image of the predetermined pattern formed on a mask on a photosensitive substrate based on invention of the above-mentioned claim 6 and a claim 7.
[0015] The process which offers the optical system manufactured by the manufacture method of optical system according to claim 8 in invention concerning a claim 9, The mask setting process of setting the aforementioned mask as the body side of the aforementioned optical system, and the substrate setting process of setting the aforementioned photosensitive substrate as the image surface of the aforementioned optical system, The lighting process which illuminates the aforementioned mask, using light with the same wavelength as the inspection light used by the inspection light or the 1st inspection process of the above used by the 1st inspection process of the above as a light for exposure, The exposure method including the projection process which projects the pattern image of the aforementioned mask on the aforementioned photosensitive substrate through the aforementioned projection optical system is offered.
[0016] In order to illuminate the mask with which the predetermined pattern was formed in invention concerning a claim 10 In the manufacture method of the aligner equipped with the light source which outputs light with predetermined criteria wavelength, and the projection optical system which projects the image of the pattern of the aforementioned mask on a photosensitive substrate It is based on the difference between the 1st environmental condition by which the aforementioned aligner is

manufactured, and the 2nd environmental condition for which the aforementioned aligner is used. The amount calculation process of adjustments which computes the amount of adjustments about the aforementioned projection optical system so that the optical-character ability of the aforementioned projection optical system may become the optimal under the 2nd environmental condition, The optical adjustment process of adjusting the aforementioned projection optical system based on the amount of adjustments about the aforementioned projection optical system obtained at the aforementioned amount calculation process of adjustments, The wavelength-adjustment process which adjusts the criteria wavelength of the light outputted from the aforementioned light source to the wavelength of a checking different light from this criteria wavelength, The manufacture method of the aligner which has the inspection process which inspects the optical property of the aforementioned projection optical system adjusted according to the aforementioned adjustment process using a checking light with the wavelength adjusted according to the aforementioned wavelength-adjustment process under the 1st environmental condition of the above is offered.

[0017] In invention concerning a claim 11, the aforementioned wavelength-adjustment process offers the manufacture method of an aligner including the wavelength calculation process of asking for the wavelength of a checking light for inspecting the optical-character ability of the aforementioned projection optical system, based on the difference between the 1st environmental condition of the above, and the 2nd environmental condition of the above based on invention of a claim 10. In order to illuminate the mask with which the predetermined pattern was formed in invention concerning a claim 12 In the manufacture method of the aligner equipped with the light source which outputs light with predetermined criteria wavelength, and the projection optical system which projects the image of the pattern of the aforementioned mask on a photosensitive substrate The 1st inspection process inspected under the 1st environmental condition of the above using light with the aforementioned criteria wavelength outputted from the aforementioned light source in the optical-character ability of the aforementioned projection optical system adjusted according to the 1st adjustment process which adjusts the aforementioned projection optical system under the 1st environmental condition, and the aforementioned 1st adjustment process, It is based on the difference between the 1st environmental condition by which the aforementioned 1st adjustment process and the 1st inspection process of the above are performed, and the 2nd environmental condition for which the aforementioned aligner is used. The amount calculation process of adjustments which computes the amount of adjustments about the aforementioned projection optical system so that the optical-character ability of the aforementioned projection optical system may become the optimal under the 2nd environmental condition, The 2nd adjustment process which adjusts the aforementioned projection optical system based on the amount of adjustments about the aforementioned projection optical system obtained at the aforementioned amount calculation process of adjustments, The wavelength-adjustment process which adjusts the criteria wavelength of the light outputted from the aforementioned light source to the wavelength of the light of the 2nd checking, The manufacture method of the aligner which has the 2nd inspection process which inspects the optical property of the aforementioned projection optical system adjusted according to the 2 aforementioned adjustment processes using the aforementioned light with the wavelength adjusted according to the aforementioned wavelength-adjustment process of the 2nd checking under the 1st environmental condition of the above is offered.

[0018] In invention concerning a claim 13, the aforementioned wavelength-adjustment process offers the manufacture method of an aligner including the wavelength calculation process of asking for the wavelength of the aforementioned light of the 2nd checking for rechecking the optical-character ability of the aforementioned projection optical system, based on the difference between the 1st environmental condition of the above, and the 2nd environmental condition of the above based on invention of a claim 12. In invention concerning a claim 14, the manufacture method of the aligner which has further the criteria wavelength setting process of setting the wavelength of the light which will be outputted from the aforementioned light source by the time it is installed in the basis of the 2nd environmental condition of the above for which the aforementioned aligner is used based on invention of any 1 term of a claim 10 or a claim 13 as the aforementioned criteria wavelength is offered.

[0019] In invention concerning a claim 15, the exposure method including the process which offers the aligner manufactured by the manufacture method of an aligner according to claim 14, the lighting process which illuminates the aforementioned mask with the criteria wavelength from the aforementioned light source, and the projection process which projects the pattern image of the aforementioned mask on the aforementioned photosensitive substrate through the aforementioned projection optical system is offered.
[0020]
[Embodiments of the Invention] As one factor of an environmental variation, change of the atmospheric pressure by the difference in elevation is mentioned. For example, if the altitude generally becomes high, atmospheric pressure will fall in connection with it. And the relation between the altitude, atmospheric pressure, and the temperature of air can be expressed by the relation shown in the following (1) formulas.
(1) h= 18400 (1+alphaT) (log B0-log B)
Here, h is the altitude (m) and B0. The atmospheric pressure (hPa) in lowlands and B are [an air expansion coefficient (alpha= 0.0036728) and T of the atmospheric pressure (hPa) in high ground and alpha] the temperature (degreeC) of the air in the altitude h.
[0021] Next, the wavelength lambda (the inside of a vacuum 0.2-1.35 micrometers) of the light in the inside of standard air (15degreeC, 1.01325 x105 Pa) and the refractive index nS of standard air A relation is given by the relation shown in the following (2) formulas.
(2) (nS-1) x108 =6432.8+2949810/(146-lambda-2)
+ 25540/(41-lambda-2)
Moreover, the temperature T (degreeC) of atmospheric pressure P (Pa) and air and the refractive index nair of air A relation is given by the relation shown in the following (3) formulas.
(3) nair =1+ [(nS-1)P (1+7.501 x10-3PbetaT) (1+15alpha)] / [1.013x105 (1+760beta15)] (1+alphaT)
Here, it is betaT. And in beta 15, the relation of betaT =(1.049-0.0157T) x10-6 and beta15=0.8135x10-6 is materialized, respectively.
[0022] And it can ask for the refractive index of the air in lowlands and high ground from the above (1) or (3) formulas. Moreover, refraction of dioptrics elements, such as a lens which constitutes the optical system in lowlands here, is considered. the refractive index of the air in now and lowlands -- the 1st of dioptrics elements, such as a lens of nL and optical system, -- wave lambda1 the receiving absolute refractive index -- the 1st to the refracting interface of dioptrics elements, such as a lens of nabs1 and optical system, -- wave lambda1 the incident angle of a beam of light -- theta 1 -- It is [of the refracting interface of dioptrics elements, such as a lens of optical system,] lambda 1 the 1st wave. When making the angle of emergence of a beam of light into theta1', in the refracting interface of a dioptrics element, the relation of the following (4) formulas is materialized from law of refraction (Snell's law).
(4) Consider refraction of dioptrics elements, such as a lens which constitutes nairLxsin theta 1 =nabs1xsin theta1' one side, next the optical system in high ground. the refractive index of the air in now and high ground -- the 1st to the refracting interface of dioptrics elements, such as a lens of nH and optical system, -- wave lambda1 the incident angle of a beam of light -- theta 2 -- It is [of the refracting interface of dioptrics elements, such as a lens of optical system,] lambda 1 the 1st wave. When making the angle of emergence of a beam of light into theta2', in the refracting interface of a dioptrics element, the relation of the following (5) formulas is materialized from law of refraction (Snell's law).
(5) nairHxsin theta 2 =nabs1xsin theta2' -- here -- theta1 =theta2 and theta 1 -- in the case of '=theta2', since the angle of refraction in lowlands and high ground is the same, the aberration generated with optical system is the same However, as long as it is nairL!=nairH, the aberration in lowlands and high ground does not become the same.
[0023] for this reason, in order to make the same angle of refraction in lowlands, and angle of refraction in high ground the 2nd to the refracting interface of dioptrics elements, such as a lens of optical system, -- wave lambda2 the incident angle of a beam of light -- theta 2 -- It is [of the refracting interface of dioptrics elements, such as a lens of optical system,] lambda 2 the 2nd wave. Dioptrics elements, such as a lens of theta2' and optical system, are the angle of emergence of a beam of light the 2nd wave

lambda 2 What is necessary is just to satisfy the relation of the following (6) formulas, when setting the receiving absolute refractive index to nabs2.
(6) The following (7) formulas can be derived from the relation between the nairLxsin theta 2 =nabs2xsin theta2', therefore above (5) formula and the above-mentioned (6) formula.
(7) nabs2=nairLxnabs1/nairH -- as mentioned above, where optical system is put on lowlands The light supplied from the light source is lambda 1 the 1st wave. By making it change to the 2nd wave with which the absolute refractive index of the dioptrics element which constitutes optical system is equivalent to the above-mentioned (7) formula Adjustment and evaluation can be carried out on the same conditions as the state where the optical-character ability of optical system was put on high ground, without using equipment with a large-scale atmospheric pressure adjustable chamber etc. for the whole optical equipment, such as an aligner.
[0024] In addition, in order to adjust and evaluate the optical-character ability of optical system to accuracy more in this case, it is desirable for all the dioptrics elements that constitute optical system to consist of the same distributions, i.e., the ** material of the same kind. Now, the gestalt of operation of this invention is explained below, referring to drawing 1 and drawing 2 .
[0025] Drawing 1 is the rough block diagram of the aligner by the gestalt of operation of this invention. As shown in drawing 1 , the light source 1 is 248nm. A KrF excimer laser and 193nm which oscillates a laser beam with wavelength It consists of laser light sources, such as an ArF excimer laser which oscillates a laser beam with wavelength. The light supplied from the light source 1 illuminates uniformly the mask with which the predetermined circuit pattern was formed through the lighting optical system 12.
[0026] Although not illustrated in drawing 1 , in addition, the lighting optical system 12 The beam plastic surgery optical system which operates the diameter of the flux of light from the light source 1 (or cross-section configuration of the flux of light) orthopedically in the diameter of the flux of light of a suitable size (or cross-section configuration of the flux of light), The optical integrator system which forms much light sources in response to the light from the beam plastic surgery optical system (one or more fly eye lenses or cylindrical optical member of the shape of an internal reflection type rod), The light from two or more light sources from the optical integrator system is condensed, respectively, and it has the capacitor optical system which illuminates a mask 13 in superposition.
[0027] Now, the pattern image of the mask 13 illuminated by the lighting optical system 12 is imprinted by the photosensitive substrates (wafer etc.) 14 by the projection optical system 14 (exposure). Here, the projection optical system 14 consists of a refracted type projection optical system which consists of many refraction system optical elements, or a reflective refraction type projection optical system which consists of combination of many refraction system optical elements and the reflected type optical elements (a concave mirror, convex mirror, etc.) of at least one or more sheets.
[0028] Drawing 2 shows the structure of the excimer laser as the light source 11 of an aligner shown in drawing 1 . As shown in drawing 2 , the excimer laser has wavelength ****** which ****** wavelength of the laser beam outputted from the excimer laser oscillation section 23 including a resonator, the excimer laser oscillation section (laser chamber) 23 and the prism 22 containing a discharge electrode etc., and the reflected type diffraction grating 21. And the ******(ed) laser beam which is injected from an excimer laser is led to the lighting optical system 12 shown in drawing 1 .
[0029] moreover, the optical division which branches the one section of the laser beam outputted from an excimer laser to the injection side of the laser beam outputted from an excimer laser -- a member 25 arranges -- having -- optical division -- the reflective direction of a member 25 -- optical division -- the wavelength monitor 24 as wavelength detection equipment which supervises the wavelength of the laser beam which reflected the member 25 is formed As for this wavelength monitor 24, the wavelength of a laser beam is measured using optical elements, such as this etalon, including optical elements, such as an etalon. Furthermore, when the output wavelength of the laser beam measured by this wavelength monitor 24 is not suitable, The amount calculation section 26 of adjustments (the amount of adjustments of wavelength ****** is computed) which computes the prism 22 in wavelength ******, and the inclination (angle) of the reflected type diffraction grating 21 based on the information measured by the

wavelength monitor 24, Based on the information from this amount calculation section of adjustments, the prism 22 and the reflected type diffraction grating 21 in wavelength ****** are formed in the suitable mechanical component 27 set up for inclining (angle), respectively.

[0030] In addition, input, such as wavelength which should be set up, is inputted into the amount calculation section 26 of adjustments through the input sections 28, such as a console, and the amount calculation section 26 of adjustments computes the amount of wavelength adjustments about a wavelength-adjustment means (prism 22 and reflected type diffraction grating 21) based on the measurement information from the wavelength monitor 24, and the input from the input section 28. By using the excimer laser equipped with the output wavelength-adjustment mechanism shown in the above drawing 2 as the light source, the light of suitable wavelength can be led to the lighting optical system 12 and a projection optical system 14.

[0031] It explains referring to drawing 3 about the evaluation method of the projection optical system 14 by this invention by the aligner shown in the above drawing 1 and drawing 2 .

[Step 1] In lowlands, the projection optical system 14 setting up was finished by many optical members (a lens, lens attachment component, etc.) is adjusted. That is, the interval between the optical faculty material which constitutes a projection optical system 14 for the aberration generated according to a manufacture error, an assembly error, etc. of the optical faculty material which constitutes a projection optical system 13 in an amendment sake (for example, interval between lenses) is changed, or a projection optical system 14 is adjusted by making the variation rate of the optical member which constitutes a projection optical system 14 from this step 1 carry out in the direction which intersects perpendicularly with an inclination or an optical axis etc.

[Step 2] In order to check whether the projection optical system 14 adjusted in the above-mentioned step 1 is filling predetermined optical-character ability (image formation performance) in the environmental condition of lowlands, at Step 2, optical-character ability of a projection optical system 14 is inspected (or evaluation). The optical-character ability of a projection optical system 14 is estimated by the technique of trial exposure for example. With trial exposure, as shown in drawing 1 , a projection optical system 14 is once attached in an aligner main part, the test mask 13 with which the predetermined test pattern was formed in the body side of a projection optical system 14 is set up, and the photosensitive substrates (wafer with which the resist was applied) 15 are set as the image surface of a projection optical system 14. And as shown in drawing 1 , the test mask 13 is illuminated for the light from the light source 1 through the lighting optical system 12, and the test pattern image of the test mask 13 is imprinted to the photosensitive substrate 15 through a projection optical system 14. Then, the optical-character ability of a projection optical system 14 can be evaluated for the test pattern image imprinted on the photosensitive substrate 15 observation and by measuring using observation equipments, such as an electron microscope.

[0032] In addition, it does not restrict to the technique of the trial exposure as technique which inspects optical-character ability of a projection optical system 14 (evaluation). For example, a test mask is set as the body side of a projection optical system 14, the processor which performs predetermined signal processing in the image surface of a projection optical system 14 or it, and a conjugate position to the output signal from the detection system which carries out photoelectrical detection of the image of a test mask, and its detection system is arranged, and light with the wavelength for exposure is illuminated on the above-mentioned test mask. Thereby, it can be based on processing information from the processor, and optical-character ability of a projection optical system 14 can be detected and evaluated in photoelectricity. Furthermore, optical-character ability of a projection optical system 14 can also be inspected also by the interferometer systems using light with the wavelength for exposure (evaluation).

[0033] Here, as a result of the technique stated above estimating the optical-character ability of a projection optical system 14, when the optical-character ability of a projection optical system 14 is not filling predetermined optical-character ability, it returns to the above-mentioned step 1 again, and adjustment of a projection optical system 14 is performed again. Moreover, when the optical-character ability of a projection optical system 14 is filling predetermined optical-character ability, it shifts to the following step 3.

[Step 3] At Step 3, it computes in the 1st sub step first based on the difference in the atmospheric pressure as one of the differences in the environmental condition of lowlands and high ground about the refractive index of the air in lowlands, and the refractive index of the air in high ground. Next, in the 2nd sub step, the amount of offset for the high grounds of a projection optical system 14 is computed based on the refractive index of the air in the lowlands called for at the lens data after adjustment of the projection optical system 14 which passed through the above-mentioned step 2, and the 1st sub step, the refractive index of the air in high ground, and the amount of wavelength change. It explains concretely, giving one example to below about each sub step.
(1st sub step) In the 1st sub step, it computes based on the atmospheric pressure difference of lowlands and high ground about the amount of wavelength change of the light outputted from the refractive index of the air in lowlands, the refractive index of the air in high ground and the object for evaluation, or the light source for exposure.
[0034] The altitude in the point (lowlands) which performs adjustment of the projection optical system 14 of an aligner, and evaluation First, above sea level [of 50m], The altitude in the point (high ground) which installs an aligner and actually uses this Above sea level [of 1000m], The wavelength lambda of the light oscillated from 23degreeC and the excimer laser which is the light source of an aligner in the temperature (setting temperature of an aligner) of the air in lowlands and high ground 0.2484 micrometers, atmospheric pressure with an altitude of 0m (above sea level [of 0m]) -- one atmospheric pressure (1013. 25hPa) and the atmospheric pressure in a point with an altitude of 50m (lowlands) -- BL ** -- if it carries out -- atmospheric pressure BL in a point with an altitude of 50m (lowlands) It becomes like (8) formulas shown below from (1) formula mentioned above.
(8) BL =1007.4207hPa -- again -- the atmospheric pressure in a point with an altitude of 1000m (high ground) -- BH ** -- if it carries out -- atmospheric pressure BH in a point with an altitude of 1000m (high ground) It becomes like (9) formulas shown below from (1) formula mentioned above.
(9) The rate of an optical refraction whose wavelength to standard air (temperature : 15degreeC, atmospheric pressure : 1.01325x105 Pa= 1013.25 hPa) is 0.2484 micrometers becomes 902.8221 hPa again like BH =(10) shown below from above-mentioned (2) formula formula.
(10) The refractive index nairL of the air of 23 degreeC to 1.0003019, therefore the light whose wavelength in a point (lowlands) with an altitude of 50m is 0.2484 micrometers becomes like nS =(11) shown below formula by substituting the value of the above-mentioned (8) formula and (10) formulas for the above-mentioned (3) formula.
(11) The refractive index nairH of the air of 23 degreeC to the light nairL=1.0002920 one side and whose wavelength with an above sea level of 1000m are 0.2484 micrometers becomes like (12) formulas shown below by substituting the value of the above-mentioned (9) formula and (10) formulas for the above-mentioned (3) formula.
(12) The refractive index of the air under the environmental condition of the lowlands obtained at the 1st sub step more than nairH=1.0002617 (2nd sub step) (nairL=1.0002920), The amount of adjustments or adjustment value for high grounds is calculated so that the image formation performance in high ground may become the optimal about at least one of two or more of the optical elements which constitute the projection optical system 14 shown in drawing 1 based on the refractive index (nairH=1.0002617) of the air under the environmental condition of high ground.
[0035] Here, the lens data of a projection optical system 14 shown in drawing 4 are hung up over Table 1 as an example. It is a thing in the state where, as for the lens data shown in following Table 1, the optical-character ability in lowlands was fully pulled out through the (evaluation process) in the inspection man under the environmental condition of the adjustment process of the above-mentioned step 1, and the lowlands of the above-mentioned step 2. In Table 1, B shows the projection scale factor of a projection optical system, and NA shows the number of the lens with which the sequence of the lens side from a body (reticle 13) side and r show the interval of each lens side, and a left end sign to the radius of curvature of a lens side, and d shows the distance (length between object images) from the body side R (reticle 13) to the image surface W (wafer 15), and a left end number to drawing 3 for the numerical aperture by the side of the image of a projection optical system However, all the lenses shown

in Table 1 consist of synthetic quartz, and the refractive index of the synthetic quartz to the light whose wavelength lambda is 0.2484 micrometers is 1.5083900.

〔表1〕

Ｂ＝１／５、ＮＡ＝０．５５、Ｌ＝１２００

	r	d	
0	∞	104.71662	R
1	955.26796	23.00000	L1
2	-675.53148	20.81278	(空気)
3	788.04209	24.00000	L2
4	-320.77870	7.92536	(空気)
5	-261.99847	20.00000	L3
6	-613.40707	1.04750	(空気)
7	343.77433	27.00000	L4
8	-614.74297	0.97572	(空気)
9	220.40014	24.00000	L5
10	111.87626	27.04713	(空気)
11	230.00000	23.00000	L6
12	-410.00000	1.10686	(空気)
13	-2449.05000	17.00000	L7
14	118.87129	18.76700	(空気)
15	-632.77988	12.90000	L8
16	143.15226	26.88549	(空気)
17	-108.88557	15.00000	L9
18	595.22400	52.22565	(空気)
19	1526.21000	35.00000	L10
20	-168.52598	14.91509	(空気)
21	-120.87196	22.80000	L11
22	-188.10351	2.79782	(空気)
23	-3191.22000	27.00000	L12
24	-296.62706	2.87255	(空気)
25	697.45117	28.00000	L13
26	-669.27158	2.49780	(空気)
27	358.82454	27.00000	L14
28	-2986.21000	1.64701	(空気)
29	223.50971	31.00000	L15
30	-1510.16000	8.60527	(空気)
31	-3596.81000	21.00000	L16
32	141.11696	9.76890	(空気)
33	194.35300	17.00000	L17
34	157.66411	31.54706	(空気)
35	-209.96142	15.90000	L18
36	307.10883	56.68624	(空気)
37	-175.13115	18.00000	L19
38	-1162.95000	6.28784	(空気)
39	-505.38166	23.00000	L20
40	-213.39177	1.14438	(空気)
41	3114.45000	23.00000	L21

42	-339.03822	2.92283	(空気)
43	460.54759	40.00000	L22
44	-326.27369	9.43498	(空気)
45	-231.89968	27.00000	L23
46	-372.57441	1.10071	(空気)
47	390.03678	28.00000	L24
48	-1994.66000	4.83032	(空気)
49	182.18377	29.00000	L25
50	525.45378	3.29194	(空気)
51	138.67730	39.00000	L26

The aberration view of a projection optical system shown in ________ is shown in ________ and ________ . (a) in ________ and (b) show the situation of the spherical aberration acquired based on the lens data shown in the above-mentioned table 1. In ________ , drawing showing the situation [as opposed to the wavelength of lambda= 0.2484 micrometers (the 1st wave) in a point (lowlands) with an altitude of 50m in (a)] of spherical aberration and (b) are drawings showing the situation of spherical aberration to the wavelength of lambda= 0.2484 micrometers (the 1st wave) in a point (high ground) with an altitude of 1000m. However, the spherical-aberration view shown in ________ (a) and ________ (b) is a thing at the time of setting the refractive index of the air of the lens data shown in Table 1 to nairL=1.0002920 (refractive index of the air in lowlands with an altitude of 50m shown by the above-mentioned (11) formula).
[0036] Moreover, (a) in ________ and (b) show the situation of the distortion aberration acquired based on the lens data shown in the above-mentioned table 1. In ________
opposed to the wavelength of lambda= 0.2484 micrometers (the 1st wave) in a point (lowlands) with an altitude of 50m in (a)] of distortion aberration and (b) are drawings showing the situation of distortion aberration to the wavelength of lambda= 0.2484 micrometers (the 1st wave) in a point (high ground) with an altitude of 1000m. However, the distortion aberration view of ________ (a) and ________
a thing at the time of setting the refractive index of the air of the lens data shown in Table 1 to nairH=1.0002617 (refractive index of the air in high ground with an altitude of 1000m shown by the above-mentioned (12) formula).
[0037] As mentioned above, as shown in ________ (a) and ________ (a), as for the projection optical system shown in Table 1, it turns out that aberration is amended good at a point (lowlands) with an altitude of 50m. However, as shown in ________ (b) and ________ (b), that aberration is getting worse
5 micrometers of spherical aberration have occurred at the maximum cuts the projection optical system shown in Table 1 by **.
[0038] Thus, in the situation which many aberration, such as big spherical aberration and distortion aberration, has generated, optical-character ability of a request of a projection optical system cannot be demonstrated. Therefore, in a projection optical system, it is necessary to give the offset for high grounds with an altitude of 1000m to beforehand. Then, at the 2nd sub step, in order to pull out good optical-character ability at a point (high ground) with an altitude of 1000m, the amount of adjustments

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the evaluation method of the projection optical system in the aligner which manufactures a semiconductor device and a liquid crystal display element according to an optical lithography process preferably especially about the evaluation method of optical system.
[0002]
[Description of the Prior Art] In order to manufacture elements, such as a semiconductor device and a liquid crystal display element, the aligner which carries out projection exposure of the mask as the projection original edition with which the predetermined pattern was formed on a photosensitive substrate through a projection optical system is used. The reflective refraction type projection optical system constituted combining lenses, such as a refracted type projection optical system which consists of lenses which have a penetrable optical property to the light of exposure wavelength as a projection optical system of such an aligner, such as an optical element of refractility, or an optical element of refractility, and the mirror as an optical element of reflection nature is used.
[0003] On the other hand, in recent years, the degree of integration of the element represented by a semiconductor device, the liquid crystal display element, etc. increases, and detailed-izing also of the pattern imprinted on a photosensitive substrate is being enhanced. And in order to realize the aligner for manufacturing various kinds of elements including the aligner which can imprint the pattern of a mask good to a photosensitive substrate, and a semiconductor device with a further more high degree of integration, the very high optical-character ability which has higher resolution in the projection optical system in an aligner is required.
[0004] In order to attain higher resolution, it is beginning to be used from the conventional extra-high pressure mercury lamp to which the light source which supplies exposure light also emits light in g line (436nm) or i line (365nm) as soon as the numerical aperture (NA) of a projection optical system is large in an excimer laser with more short wavelength etc. The place which these aligners are installed and is actually used is not necessarily the same as the environmental condition to which adjustment and evaluation of the projection optical system of an aligner were carried out. For example, compared with the altitude to which adjustment and evaluation of the projection optical system of an aligner were performed, far, the place which an aligner is installed and is actually used has the high altitude, and turns into a low place of average atmospheric pressure in many cases.
[0005]
[Problem(s) to be Solved by the Invention] Generally the atmospheric pressure from which the altitude changes changes, and the refractive index of air changes in connection with it. And if the refractive index of air changes, in the optical element of refractility, such as a lens, etc., the angle of refraction of the beam of light in a refracting interface will change, consequently the image formation performance of optical system will change.
[0006] In the former, when the altitude (it is hereafter called lowlands.) which performs adjustment of

the projection optical system of an aligner and evaluation differs from the altitude (it is hereafter called high ground.) for which an aligner is actually installed and used, in lowlands, a projection optical system is once made into a desired image formation performance by adjustment etc. Then, the lens interval of a projection optical system is changed, for example, and in the state where the aligner was moved and installed in high ground, the image formation performance of a projection optical system is intentionally changed so that the image formation performance of a request of a projection optical system can be reproduced.

[0007] However, when the aberration offset for different altitude in a projection optical system is added, the image formation performance of a projection optical system gets worse, and exact evaluation of the image formation performance of a projection optical system becomes difficult in lowlands. For this reason, in order for an aligner to check beforehand the optical-character ability of the projection optical system in the place actually installed and used in lowlands, a large-scale facility and large-scale time, such as an atmospheric pressure adjustable game par which can contain the whole aligner, are needed.

[0008] Then, this invention aims at offering the manufacture method of the inspection method of optical system that the image-formation performance of optical system, such as a projection optical system, can be adjusted and estimated that equipment becomes the same as the environmental condition installed and used also under a different environmental condition from the environmental condition for which it is made in view of the above technical problem, and optical equipments, such as an aligner, are actually installed and used, the optical system using the inspection method, and an aligner.

[0009]

[The means for solving invention] In order to attain the above purpose, in invention concerning a claim 1 The wavelength-adjustment process which adjusts the wavelength of the inspection light for inspecting the optical-character ability of the aforementioned optical system based on the difference between the 1st environmental condition by which the optical-character ability of optical system is inspected, and the 2nd environmental condition for which the aforementioned optical system is used, The inspection method of optical system of having the inspection process which inspects the optical-character ability of the aforementioned optical system using inspection light with the wavelength adjusted according to the aforementioned wavelength-adjustment process is offered.

[0010] The 1st inspection process which inspects the optical-character ability of optical system under the 1st environmental condition in invention concerning a claim 2 using the 1st inspection light with the 1st wave, The amount calculation process of adjustments which computes the amount of adjustments about the aforementioned optical system so that the optical-character ability of the aforementioned optical system may become the optimal under the 2nd environmental condition for which the aforementioned optical system is used, The optical adjustment process of adjusting the aforementioned optical system based on the amount of adjustments about the aforementioned optical system obtained at the aforementioned amount calculation process of adjustments, The manufacture method of optical system of having the 2nd inspection process which inspects the optical-character ability of the aforementioned optical system adjusted according to the aforementioned optical adjustment process under the 1st environmental condition of the above is offered using the 2nd inspection light with the 2nd different predetermined wave from the inspection light of the 1st aforementioned wave.

[0011] In invention concerning a claim 3, it is based on the difference between the 1st environmental condition by which the optical-character ability of optical system is inspected, and the 2nd environmental condition for which the aforementioned optical system is used. The amount calculation process of adjustments which computes the amount of adjustments about the aforementioned optical system so that the optical-character ability of the aforementioned optical system may become the optimal under the 2nd environmental condition, The optical adjustment process of adjusting the aforementioned optical system based on the amount of adjustments about the aforementioned optical system obtained at the aforementioned amount calculation process of adjustments, The wavelength-adjustment process which adjusts the wavelength of a checking light for inspecting the optical-character ability of the aforementioned optical system The manufacture method of optical system of having the inspection process which inspects the optical property of the aforementioned optical system adjusted

according to the aforementioned optical adjustment process using a checking light with the wavelength adjusted according to the aforementioned wavelength-adjustment process under the 1st environmental condition of the above is offered.
[0012] In invention concerning a claim 4, the aforementioned wavelength-adjustment process offers the manufacture method of optical system including the wavelength calculation process of asking for the wavelength of the checking aforementioned light based on the difference between the 1st environmental condition and the 2nd environmental condition of the above, based on invention of the above-mentioned claim 3. In invention concerning a claim 5, the manufacture method of the optical system which is a projection optical system which projects the image of the predetermined pattern with which the aforementioned optical system is formed on a mask on a photosensitive substrate is offered based on invention of the above-mentioned claim 3 and a claim 4.
[0013] The 1st adjustment process which adjusts optical system under the 1st environmental condition in invention concerning a claim 6, The 1st inspection process which inspects the optical-character ability of the aforementioned optical system adjusted according to the aforementioned 1st adjustment process under the 1st environmental condition of the above using inspection light with predetermined wavelength, It is based on the difference between the 1st environmental condition by which the aforementioned 1st adjustment process and the 1st inspection process of the above are performed, and the 2nd environmental condition for which the aforementioned optical system is used. The amount calculation process of adjustments which computes the amount of adjustments about the aforementioned optical system so that the optical-character ability of the aforementioned optical system may become the optimal under the 2nd environmental condition of the above, The 2nd adjustment process which adjusts the aforementioned optical system based on the amount of adjustments about the aforementioned optical system obtained at the aforementioned amount calculation process of adjustments, The manufacture method of optical system of having the wavelength-adjustment process which adjusts the wavelength of the aforementioned inspection light, and the 2nd inspection process which rechecks the optical property of the aforementioned optical system adjusted according to the aforementioned 2nd adjustment process using the inspection light adjusted according to the aforementioned wavelength-adjustment process under the 1st environmental condition of the above is offered.
[0014] In invention concerning a claim 7, the aforementioned wavelength-adjustment process offers the manufacture method of optical system including the wavelength calculation process of asking for the wavelength of the inspection light for rechecking the optical-character ability of the aforementioned optical system, based on the difference between the 1st environmental condition of the above, and the 2nd environmental condition of the above based on invention of a claim 6. In invention concerning a claim 8, the aforementioned optical system offers the manufacture method of the optical system which is a projection optical system which projects the image of the predetermined pattern formed on a mask on a photosensitive substrate based on invention of the above-mentioned claim 6 and a claim 7.
[0015] The process which offers the optical system manufactured by the manufacture method of optical system according to claim 8 in invention concerning a claim 9, The mask setting process of setting the aforementioned mask as the body side of the aforementioned optical system, and the substrate setting process of setting the aforementioned photosensitive substrate as the image surface of the aforementioned optical system, The lighting process which illuminates the aforementioned mask, using light with the same wavelength as the inspection light used by the inspection light or the 1st inspection process of the above used by the 1st inspection process of the above as a light for exposure, The exposure method including the projection process which projects the pattern image of the aforementioned mask on the aforementioned photosensitive substrate through the aforementioned projection optical system is offered.
[0016] In order to illuminate the mask with which the predetermined pattern was formed in invention concerning a claim 10 In the manufacture method of the aligner equipped with the light source which outputs light with predetermined criteria wavelength, and the projection optical system which projects the image of the pattern of the aforementioned mask on a photosensitive substrate It is based on the difference between the 1st environmental condition by which the aforementioned aligner is

manufactured, and the 2nd environmental condition for which the aforementioned aligner is used. The amount calculation process of adjustments which computes the amount of adjustments about the aforementioned projection optical system so that the optical-character ability of the aforementioned projection optical system may become the optimal under the 2nd environmental condition, The optical adjustment process of adjusting the aforementioned projection optical system based on the amount of adjustments about the aforementioned projection optical system obtained at the aforementioned amount calculation process of adjustments, The wavelength-adjustment process which adjusts the criteria wavelength of the light outputted from the aforementioned light source to the wavelength of a checking different light from this criteria wavelength, The manufacture method of the aligner which has the inspection process which inspects the optical property of the aforementioned projection optical system adjusted according to the aforementioned adjustment process using a checking light with the wavelength adjusted according to the aforementioned wavelength-adjustment process under the 1st environmental condition of the above is offered.

[0017] In invention concerning a claim 11, the aforementioned wavelength-adjustment process offers the manufacture method of an aligner including the wavelength calculation process of asking for the wavelength of a checking light for inspecting the optical-character ability of the aforementioned projection optical system, based on the difference between the 1st environmental condition of the above, and the 2nd environmental condition of the above based on invention of a claim 10. In order to illuminate the mask with which the predetermined pattern was formed in invention concerning a claim 12 In the manufacture method of the aligner equipped with the light source which outputs light with predetermined criteria wavelength, and the projection optical system which projects the image of the pattern of the aforementioned mask on a photosensitive substrate The 1st inspection process inspected under the 1st environmental condition of the above using light with the aforementioned criteria wavelength outputted from the aforementioned light source in the optical-character ability of the aforementioned projection optical system adjusted according to the 1st adjustment process which adjusts the aforementioned projection optical system under the 1st environmental condition, and the aforementioned 1st adjustment process, It is based on the difference between the 1st environmental condition by which the aforementioned 1st adjustment process and the 1st inspection process of the above are performed, and the 2nd environmental condition for which the aforementioned aligner is used. The amount calculation process of adjustments which computes the amount of adjustments about the aforementioned projection optical system so that the optical-character ability of the aforementioned projection optical system may become the optimal under the 2nd environmental condition, The 2nd adjustment process which adjusts the aforementioned projection optical system based on the amount of adjustments about the aforementioned projection optical system obtained at the aforementioned amount calculation process of adjustments, The wavelength-adjustment process which adjusts the criteria wavelength of the light outputted from the aforementioned light source to the wavelength of the light of the 2nd checking, The manufacture method of the aligner which has the 2nd inspection process which inspects the optical property of the aforementioned projection optical system adjusted according to the 2 aforementioned adjustment processes using the aforementioned light with the wavelength adjusted according to the aforementioned wavelength-adjustment process of the 2nd checking under the 1st environmental condition of the above is offered.

[0018] In invention concerning a claim 13, the aforementioned wavelength-adjustment process offers the manufacture method of an aligner including the wavelength calculation process of asking for the wavelength of the aforementioned light of the 2nd checking for rechecking the optical-character ability of the aforementioned projection optical system, based on the difference between the 1st environmental condition of the above, and the 2nd environmental condition of the above based on invention of a claim 12. In invention concerning a claim 14, the manufacture method of the aligner which has further the criteria wavelength setting process of setting the wavelength of the light which will be outputted from the aforementioned light source by the time it is installed in the basis of the 2nd environmental condition of the above for which the aforementioned aligner is used based on invention of any 1 term of a claim 10 or a claim 13 as the aforementioned criteria wavelength is offered.

[0019] In invention concerning a claim 15, the exposure method including the process which offers the aligner manufactured by the manufacture method of an aligner according to claim 14, the lighting process which illuminates the aforementioned mask with the criteria wavelength from the aforementioned light source, and the projection process which projects the pattern image of the aforementioned mask on the aforementioned photosensitive substrate through the aforementioned projection optical system is offered.
[0020]
[Embodiments of the Invention] As one factor of an environmental variation, change of the atmospheric pressure by the difference in elevation is mentioned. For example, if the altitude generally becomes high, atmospheric pressure will fall in connection with it. And the relation between the altitude, atmospheric pressure, and the temperature of air can be expressed by the relation shown in the following (1) formulas.
(1) h= 18400 (1+alphaT) (log B0-log B)
Here, h is the altitude (m) and B0. The atmospheric pressure (hPa) in lowlands and B are [an air expansion coefficient (alpha= 0.0036728) and T of the atmospheric pressure (hPa) in high ground and alpha] the temperature (degreeC) of the air in the altitude h.
[0021] Next, the wavelength lambda (the inside of a vacuum 0.2-1.35 micrometers) of the light in the inside of standard air (15degreeC, 1.01325 x105 Pa) and the refractive index nS of standard air A relation is given by the relation shown in the following (2) formulas.
(2) (nS-1) x108 =6432.8+2949810/(146-lambda-2)
+ 25540/(41-lambda-2)
Moreover, the temperature T (degreeC) of atmospheric pressure P (Pa) and air and the refractive index nair of air A relation is given by the relation shown in the following (3) formulas.
(3) nair =1+ [(nS-1)P (1+7.501 x10-3PbetaT) (1+15alpha)] / [1.013x105 (1+760beta15)] (1+alphaT)
Here, it is betaT. And in beta 15, the relation of betaT =(1.049-0.0157T) x10-6 and beta15=0.8135x10-6 is materialized, respectively.
[0022] And it can ask for the refractive index of the air in lowlands and high ground from the above (1) or (3) formulas. Moreover, refraction of dioptrics elements, such as a lens which constitutes the optical system in lowlands here, is considered. the refractive index of the air in now and lowlands -- the 1st of dioptrics elements, such as a lens of nL and optical system, -- wave lambda1 the receiving absolute refractive index -- the 1st to the refracting interface of dioptrics elements, such as a lens of nabs1 and optical system, -- wave lambda1 the incident angle of a beam of light -- theta 1 -- It is [of the refracting interface of dioptrics elements, such as a lens of optical system,] lambda 1 the 1st wave. When making the angle of emergence of a beam of light into theta1', in the refracting interface of a dioptrics element, the relation of the following (4) formulas is materialized from law of refraction (Snell's law).
(4) Consider refraction of dioptrics elements, such as a lens which constitutes nairLxsin theta 1 =nabs1xsin theta1' one side, next the optical system in high ground. the refractive index of the air in now and high ground -- the 1st to the refracting interface of dioptrics elements, such as a lens of nH and optical system, -- wave lambda1 the incident angle of a beam of light -- theta 2 -- It is [of the refracting interface of dioptrics elements, such as a lens of optical system,] lambda 1 the 1st wave. When making the angle of emergence of a beam of light into theta2', in the refracting interface of a dioptrics element, the relation of the following (5) formulas is materialized from law of refraction (Snell's law).
(5) nairHxsin theta 2 =nabs1xsin theta2' -- here -- theta1 =theta2 and theta 1 -- in the case of '=theta2', since the angle of refraction in lowlands and high ground is the same, the aberration generated with optical system is the same However, as long as it is nairL!=nairH, the aberration in lowlands and high ground does not become the same.
[0023] for this reason, in order to make the same angle of refraction in lowlands, and angle of refraction in high ground the 2nd to the refracting interface of dioptrics elements, such as a lens of optical system, -- wave lambda2 the incident angle of a beam of light -- theta 2 -- It is [of the refracting interface of dioptrics elements, such as a lens of optical system,] lambda 2 the 2nd wave. Dioptrics elements, such as a lens of theta2' and optical system, are the angle of emergence of a beam of light the 2nd wave

lambda 2 What is necessary is just to satisfy the relation of the following (6) formulas, when setting the receiving absolute refractive index to nabs2.
(6) The following (7) formulas can be derived from the relation between the nairLxsin theta 2 =nabs2xsin theta2', therefore above (5) formula and the above-mentioned (6) formula.
(7) nabs2=nairLxnabs1/nairH -- as mentioned above, where optical system is put on lowlands The light supplied from the light source is lambda 1 the 1st wave. By making it change to the 2nd wave with which the absolute refractive index of the dioptrics element which constitutes optical system is equivalent to the above-mentioned (7) formula Adjustment and evaluation can be carried out on the same conditions as the state where the optical-character ability of optical system was put on high ground, without using equipment with a large-scale atmospheric pressure adjustable chamber etc. for the whole optical equipment, such as an aligner.
[0024] In addition, in order to adjust and evaluate the optical-character ability of optical system to accuracy more in this case, it is desirable for all the dioptrics elements that constitute optical system to consist of the same distributions, i.e., the ** material of the same kind. Now, the gestalt of operation of this invention is explained below, referring to drawing 1 and drawing 2 .
[0025] Drawing 1 is the rough block diagram of the aligner by the gestalt of operation of this invention. As shown in drawing 1 , the light source 1 is 248nm. A KrF excimer laser and 193nm which oscillates a laser beam with wavelength It consists of laser light sources, such as an ArF excimer laser which oscillates a laser beam with wavelength. The light supplied from the light source 1 illuminates uniformly the mask with which the predetermined circuit pattern was formed through the lighting optical system 12.
[0026] Although not illustrated in drawing 1 , in addition, the lighting optical system 12 The beam plastic surgery optical system which operates the diameter of the flux of light from the light source 1 (or cross-section configuration of the flux of light) orthopedically in the diameter of the flux of light of a suitable size (or cross-section configuration of the flux of light), The optical integrator system which forms much light sources in response to the light from the beam plastic surgery optical system (one or more fly eye lenses or cylindrical optical member of the shape of an internal reflection type rod), The light from two or more light sources from the optical integrator system is condensed, respectively, and it has the capacitor optical system which illuminates a mask 13 in superposition.
[0027] Now, the pattern image of the mask 13 illuminated by the lighting optical system 12 is imprinted by the photosensitive substrates (wafer etc.) 14 by the projection optical system 14 (exposure). Here, the projection optical system 14 consists of a refracted type projection optical system which consists of many refraction system optical elements, or a reflective refraction type projection optical system which consists of combination of many refraction system optical elements and the reflected type optical elements (a concave mirror, convex mirror, etc.) of at least one or more sheets.
[0028] Drawing 2 shows the structure of the excimer laser as the light source 11 of an aligner shown in drawing 1 . As shown in drawing 2 , the excimer laser has wavelength ****** which ****** wavelength of the laser beam outputted from the excimer laser oscillation section 23 including a resonator, the excimer laser oscillation section (laser chamber) 23 and the prism 22 containing a discharge electrode etc., and the reflected type diffraction grating 21. And the ******(ed) laser beam which is injected from an excimer laser is led to the lighting optical system 12 shown in drawing 1 .
[0029] moreover, the optical division which branches the one section of the laser beam outputted from an excimer laser to the injection side of the laser beam outputted from an excimer laser -- a member 25 arranges -- having -- optical division -- the reflective direction of a member 25 -- optical division -- the wavelength monitor 24 as wavelength detection equipment which supervises the wavelength of the laser beam which reflected the member 25 is formed As for this wavelength monitor 24, the wavelength of a laser beam is measured using optical elements, such as this etalon, including optical elements, such as an etalon. Furthermore, when the output wavelength of the laser beam measured by this wavelength monitor 24 is not suitable, The amount calculation section 26 of adjustments (the amount of adjustments of wavelength ****** is computed) which computes the prism 22 in wavelength ******, and the inclination (angle) of the reflected type diffraction grating 21 based on the information measured by the

wavelength monitor 24, Based on the information from this amount calculation section of adjustments, the prism 22 and the reflected type diffraction grating 21 in wavelength ****** are formed in the suitable mechanical component 27 set up for inclining (angle), respectively.
[0030] In addition, input, such as wavelength which should be set up, is inputted into the amount calculation section 26 of adjustments through the input sections 28, such as a console, and the amount calculation section 26 of adjustments computes the amount of wavelength adjustments about a wavelength-adjustment means (prism 22 and reflected type diffraction grating 21) based on the measurement information from the wavelength monitor 24, and the input from the input section 28. By using the excimer laser equipped with the output wavelength-adjustment mechanism shown in the above drawing 2 as the light source, the light of suitable wavelength can be led to the lighting optical system 12 and a projection optical system 14.
[0031] It explains referring to drawing 3 about the evaluation method of the projection optical system 14 by this invention by the aligner shown in the above drawing 1 and drawing 2 .
[Step 1] In lowlands, the projection optical system 14 setting up was finished by many optical members (a lens, lens attachment component, etc.) is adjusted. That is, the interval between the optical faculty material which constitutes a projection optical system 14 for the aberration generated according to a manufacture error, an assembly error, etc. of the optical faculty material which constitutes a projection optical system 13 in an amendment sake (for example, interval between lenses) is changed, or a projection optical system 14 is adjusted by making the variation rate of the optical member which constitutes a projection optical system 14 from this step 1 carry out in the direction which intersects perpendicularly with an inclination or an optical axis etc.
[Step 2] In order to check whether the projection optical system 14 adjusted in the above-mentioned step 1 is filling predetermined optical-character ability (image formation performance) in the environmental condition of lowlands, at Step 2, optical-character ability of a projection optical system 14 is inspected (or evaluation). The optical-character ability of a projection optical system 14 is estimated by the technique of trial exposure for example. With trial exposure, as shown in drawing 1 , a projection optical system 14 is once attached in an aligner main part, the test mask 13 with which the predetermined test pattern was formed in the body side of a projection optical system 14 is set up, and the photosensitive substrates (wafer with which the resist was applied) 15 are set as the image surface of a projection optical system 14. And as shown in drawing 1 , the test mask 13 is illuminated for the light from the light source 1 through the lighting optical system 12, and the test pattern image of the test mask 13 is imprinted to the photosensitive substrate 15 through a projection optical system 14. Then, the optical-character ability of a projection optical system 14 can be evaluated for the test pattern image imprinted on the photosensitive substrate 15 observation and by measuring using observation equipments, such as an electron microscope.
[0032] In addition, it does not restrict to the technique of the trial exposure as technique which inspects optical-character ability of a projection optical system 14 (evaluation). For example, a test mask is set as the body side of a projection optical system 14, the processor which performs predetermined signal processing in the image surface of a projection optical system 14 or it, and a conjugate position to the output signal from the detection system which carries out photoelectrical detection of the image of a test mask, and its detection system is arranged, and light with the wavelength for exposure is illuminated on the above-mentioned test mask. Thereby, it can be based on processing information from the processor, and optical-character ability of a projection optical system 14 can be detected and evaluated in photoelectricity. Furthermore, optical-character ability of a projection optical system 14 can also be inspected also by the interferometer systems using light with the wavelength for exposure (evaluation).
[0033] Here, as a result of the technique stated above estimating the optical-character ability of a projection optical system 14, when the optical-character ability of a projection optical system 14 is not filling predetermined optical-character ability, it returns to the above-mentioned step 1 again, and adjustment of a projection optical system 14 is performed again. Moreover, when the optical-character ability of a projection optical system 14 is filling predetermined optical-character ability, it shifts to the following step 3.

[Step 3] At Step 3, it computes in the 1st sub step first based on the difference in the atmospheric pressure as one of the differences in the environmental condition of lowlands and high ground about the refractive index of the air in lowlands, and the refractive index of the air in high ground. Next, in the 2nd sub step, the amount of offset for the high grounds of a projection optical system 14 is computed based on the refractive index of the air in the lowlands called for at the lens data after adjustment of the projection optical system 14 which passed through the above-mentioned step 2, and the 1st sub step, the refractive index of the air in high ground, and the amount of wavelength change. It explains concretely, giving one example to below about each sub step.
(1st sub step) In the 1st sub step, it computes based on the atmospheric pressure difference of lowlands and high ground about the amount of wavelength change of the light outputted from the refractive index of the air in lowlands, the refractive index of the air in high ground and the object for evaluation, or the light source for exposure.
[0034] The altitude in the point (lowlands) which performs adjustment of the projection optical system 14 of an aligner, and evaluation First, above sea level [of 50m], The altitude in the point (high ground) which installs an aligner and actually uses this Above sea level [of 1000m], The wavelength lambda of the light oscillated from 23degreeC and the excimer laser which is the light source of an aligner in the temperature (setting temperature of an aligner) of the air in lowlands and high ground 0.2484 micrometers, atmospheric pressure with an altitude of 0m (above sea level [of 0m]) -- one atmospheric pressure (1013. 25hPa) and the atmospheric pressure in a point with an altitude of 50m (lowlands) -- BL ** -- if it carries out -- atmospheric pressure BL in a point with an altitude of 50m (lowlands) It becomes like (8) formulas shown below from (1) formula mentioned above.
(8) BL =1007.4207hPa -- again -- the atmospheric pressure in a point with an altitude of 1000m (high ground) -- BH ** -- if it carries out -- atmospheric pressure BH in a point with an altitude of 1000m (high ground) It becomes like (9) formulas shown below from (1) formula mentioned above.
(9) The rate of an optical refraction whose wavelength to standard air (temperature : 15degreeC, atmospheric pressure : 1.01325x105 Pa= 1013.25 hPa) is 0.2484 micrometers becomes 902.8221 hPa again like BH =(10) shown below from above-mentioned (2) formula formula.
(10) The refractive index nairL of the air of 23 degreeC to 1.0003019, therefore the light whose wavelength in a point (lowlands) with an altitude of 50m is 0.2484 micrometers becomes like nS =(11) shown below formula by substituting the value of the above-mentioned (8) formula and (10) formulas for the above-mentioned (3) formula.
(11) The refractive index nairH of the air of 23 degreeC to the light nairL=1.0002920 one side and whose wavelength with an above sea level of 1000m are 0.2484 micrometers becomes like (12) formulas shown below by substituting the value of the above-mentioned (9) formula and (10) formulas for the above-mentioned (3) formula.
(12) The refractive index of the air under the environmental condition of the lowlands obtained at the 1st sub step more than nairH=1.0002617 (2nd sub step) (nairL=1.0002920), The amount of adjustments or adjustment value for high grounds is calculated so that the image formation performance in high ground may become the optimal about at least one of two or more of the optical elements which constitute the projection optical system 14 shown in drawing 1 based on the refractive index (nairH=1.0002617) of the air under the environmental condition of high ground.
[0035] Here, the lens data of a projection optical system 14 shown in drawing 4 are hung up over Table 1 as an example. It is a thing in the state where, as for the lens data shown in following Table 1, the optical-character ability in lowlands was fully pulled out through the (evaluation process) in the inspection man under the environmental condition of the adjustment process of the above-mentioned step 1, and the lowlands of the above-mentioned step 2. In Table 1, B shows the projection scale factor of a projection optical system, and NA shows the number of the lens with which the sequence of the lens side from a body (reticle 13) side and r show the interval of each lens side, and a left end sign to the radius of curvature of a lens side, and d shows the distance (length between object images) from the body side R (reticle 13) to the image surface W (wafer 15), and a left end number to drawing 3 for the numerical aperture by the side of the image of a projection optical system However, all the lenses shown

in Table 1 consist of synthetic quartz, and the refractive index of the synthetic quartz to the light whose wavelength lambda is 0.2484 micrometers is 1.5083900.

〔表1〕

B＝1／5、NA＝0．55、L＝1200

	r	d	
0	∞	104.71662	R
1	955.26796	23.00000	L1
2	-675.53148	20.81278	(空気)
3	788.04209	24.00000	L2
4	-320.77870	7.92536	(空気)
5	-261.99847	20.00000	L3
6	-613.40707	1.04750	(空気)
7	343.77433	27.00000	L4
8	-614.74297	0.97572	(空気)
9	220.40014	24.00000	L5
10	111.87626	27.04713	(空気)
11	230.00000	23.00000	L6
12	-410.00000	1.10686	(空気)
13	-2449.05000	17.00000	L7
14	118.87129	18.76700	(空気)
15	-632.77988	12.90000	L8
16	143.15226	26.88549	(空気)
17	-108.88557	15.00000	L9
18	595.22400	52.22565	(空気)
19	1526.21000	35.00000	L10
20	-168.52598	14.91509	(空気)
21	-120.87196	22.80000	L11
22	-188.10351	2.79782	(空気)
23	-3191.22000	27.00000	L12
24	-296.62706	2.87255	(空気)
25	697.45117	28.00000	L13
26	-669.27158	2.49780	(空気)
27	358.82454	27.00000	L14
28	-2986.21000	1.64701	(空気)
29	223.50971	31.00000	L15
30	-1510.16000	8.60527	(空気)
31	-3596.81000	21.00000	L16
32	141.11696	9.76890	(空気)
33	194.35300	17.00000	L17
34	157.66411	31.54706	(空気)
35	-209.96142	15.90000	L18
36	307.10883	56.68624	(空気)
37	-175.13115	18.00000	L19
38	-1162.95000	6.28784	(空気)
39	-505.38166	23.00000	L20
40	-213.39177	1.14438	(空気)
41	3114.45000	23.00000	L21

42	-339.03822	2.92283	(空気)
43	460.54759	40.00000	L22
44	-326.27369	9.43498	(空気)
45	-231.89968	27.00000	L23
46	-372.57441	1.10071	(空気)
47	390.03678	28.00000	L24
48	-1994.66000	4.83032	(空気)
49	182.18377	29.00000	L25
50	525.45378	3.29194	(空気)
51	138.67730	39.90000	L26
52	312.43609	9.82671	(空気)
53	511.48346	23.00000	L27
54	81.45867	7.04896	(空気)
55	93.64185	34.00000	L28
56	934.34560	2.00000	(空気)
57	826.70065	35.00000	L29
58	1680.21000	28.76320	(空気)
59	∞		W

The aberration view of a projection optical system shown in drawing 4 is shown in drawing 5 and drawing 6 . (a) in drawing 5 and (b) show the situation of the spherical aberration acquired based on the lens data shown in the above-mentioned table 1. In drawing 5 , drawing showing the situation [as opposed to the wavelength of lambda= 0.2484 micrometers (the 1st wave) in a point (lowlands) with an altitude of 50m in (a)] of spherical aberration and (b) are drawings showing the situation of spherical aberration to the wavelength of lambda= 0.2484 micrometers (the 1st wave) in a point (high ground) with an altitude of 1000m. However, the spherical-aberration view shown in drawing 5 (a) and drawing 6 (b) is a thing at the time of setting the refractive index of the air of the lens data shown in Table 1 to nairL=1.0002920 (refractive index of the air in lowlands with an altitude of 50m shown by the above-mentioned (11) formula).
[0036] Moreover, (a) in drawing 6 and (b) show the situation of the distortion aberration acquired based on the lens data shown in the above-mentioned table 1. In drawing 6 , drawing showing the situation [as opposed to the wavelength of lambda= 0.2484 micrometers (the 1st wave) in a point (lowlands) with an altitude of 50m in (a)] of distortion aberration and (b) are drawings showing the situation of distortion aberration to the wavelength of lambda= 0.2484 micrometers (the 1st wave) in a point (high ground) with an altitude of 1000m. However, the distortion aberration view of drawing 6 (a) and drawing 6 (b) is a thing at the time of setting the refractive index of the air of the lens data shown in Table 1 to nairH=1.0002617 (refractive index of the air in high ground with an altitude of 1000m shown by the above-mentioned (12) formula).
[0037] As mentioned above, as shown in drawing 5 (a) and drawing 6 (a), as for the projection optical system shown in Table 1, it turns out that aberration is amended good at a point (lowlands) with an altitude of 50m. However, as shown in drawing 5 (b) and drawing 6 (b), that aberration is getting worse at a point (high ground) with an altitude of 1000m, for example, -5 micrometers of spherical aberration have occurred at the maximum cuts the projection optical system shown in Table 1 by **.
[0038] Thus, in the situation which many aberration, such as big spherical aberration and distortion aberration, has generated, optical-character ability of a request of a projection optical system cannot be demonstrated. Therefore, in a projection optical system, it is necessary to give the offset for high grounds with an altitude of 1000m to beforehand. Then, at the 2nd sub step, in order to pull out good optical-character ability at a point (high ground) with an altitude of 1000m, the amount of adjustments or adjustment value of each optical element (lens) which constitutes the projection optical system shown

in drawing 4 is calculated. the lens data with which the amount of adjustments or adjustment value of each optical element (lens) is shown in Table 1 using arithmetic units, such as a computer, -- being based -- design automation, such as ray tracing, -- a line -- it asks by things When design automation is carried out [ray tracing] at this time, the refractive index of the air of Table 1 is a refractive index (nairH=1.0002617) of the air in high ground with an altitude of 1000m, as the above-mentioned (12) formula showed.

[0039] In the following table 2, the lens data in which the adjustment value for the high grounds of the optical element (lens) which constitutes the projection optical system called for with arithmetic units, such as a computer, based on the lens data shown in Table 1 is shown are hung up. the example shown in Table 2 -- a point (high ground) with an altitude of 1000m -- setting -- fitness -- in order to pull out optical-character ability, the lens interval (air interval) of lens L2 -L29 shown in Table 1 is changed slightly, and the lens data in the state where the aberration offset for high grounds was added are shown Here, Table 2 shows the value of the lens interval (air interval) of lens L2 -L29 as an adjustment value of a lens.

〔表２〕

Ｂ＝１／５、ＮＡ＝０．５５、Ｌ＝１２００

	r	d	
0	∞	104.71662	R
1	955.26796	23.00000	L1
2	-675.53148	20.81327	(空気)
3	788.04209	24.00000	L2
4	-320.77870	7.92688	(空気)
5	-261.99847	20.00000	L3
6	-613.40707	1.05238	(空気)
7	343.77433	27.00000	L4
8	-614.74297	0.98439	(空気)
9	220.40014	24.00000	L5
10	111.87626	27.05197	(空気)
11	230.00000	23.00000	L6
12	-410.00000	1.11599	(空気)
13	-2449.05000	17.00000	L7
14	118.87129	18.76715	(空気)
15	-632.77988	12.90000	L8
16	143.15226	26.88300	(空気)
17	-108.88557	15.00000	L9
18	595.22400	52.22598	(空気)
19	1526.21000	35.00000	L10
20	-168.52598	14.91713	(空気)
21	-120.87196	22.80000	L11
22	-188.10351	2.79542	(空気)
23	-3191.22000	27.00000	L12
24	-296.62706	2.87454	(空気)
25	697.45117	28.00000	L13
26	-669.27158	2.50251	(空気)
27	358.82454	27.00000	L14
28	-2986.21000	1.65252	(空気)
29	223.50971	31.00000	L15
30	-1510.16000	8.59879	(空気)
31	-3596.81000	21.00000	L16
32	141.11696	9.76690	(空気)
33	194.35300	17.00000	L17
34	157.66411	31.54381	(空気)
35	-209.96142	15.90000	L18
36	307.10883	56.68480	(空気)
37	-175.13115	18.00000	L19
38	-1162.95000	6.27984	(空気)
39	-505.38166	23.00000	L20
40	-213.39177	1.14425	(空気)
41	3114.45000	23.00000	L21

42	-339.03822	2.92562	(空気)
43	460.54759	40.00000	L22
44	-326.27369	9.43390	(空気)
45	-231.89968	27.00000	L23
46	-372.57441	1.10621	(空気)
47	390.03678	28.00000	L24
48	-1994.66000	4.83821	(空気)
49	182.18377	29.00000	L25
50	525.45378	3.29556	(空気)
51	138.67730	39.90000	L26
52	312.43609	9.82752	(空気)
53	511.48346	23.00000	L27
54	81.45867	7.05951	(空気)
55	93.64185	34.00000	L28
56	934.34560	1.99581	(空気)
57	826.70065	35.00000	L29
58	1680.21000	28.74943	(空気)
59	∞		W

(c) in drawing 5 and (d) show the situation of the spherical aberration acquired based on the lens data shown in the above-mentioned table 2. [when (c) gives the aberration offset which is the altitude of 1000m and which is turned a point (high ground) to a projection optical system in drawing 5] [when drawing showing the situation of the spherical aberration under the environmental condition in the lowlands to the wavelength of lambda= 0.2484 micrometers (the 1st wave) and (b) give the aberration offset which is the altitude of 1000m and which is turned a point (high ground) to a projection optical system] It is drawing showing the situation of the spherical aberration under the environmental condition in the high ground to the wavelength of lambda= 0.248318 micrometers (the 2nd wave). However, the spherical-aberration view which the spherical-aberration view shown in drawing 5 (c) is a thing at the time of setting to nairL=1.0002920 (refractive index of the air in lowlands with an altitude of 50m) the refractive index of the air of the lens data shown in Table 2, and is shown in drawing 5 (d) is a thing at the time of setting to nairH=1.0002617 (refractive index of the air in high ground with an altitude of 1000m) the refractive index of the air of the lens data shown in Table 2.

[0040] Moreover, (c) in drawing 6 and (d) show the situation of the spherical aberration acquired based on the lens data shown in the above-mentioned table 2. [when (c) gives the aberration offset which is the altitude of 1000m and which is turned a point (high ground) to a projection optical system in drawing 6] [when drawing showing the situation of the distortion aberration under the environmental condition in the lowlands to the wavelength of lambda= 0.2484 micrometers (the 1st wave) and (b) give the aberration offset which is the altitude of 1000m and which is turned a point (high ground) to a projection optical system] It is drawing showing the situation of the distortion aberration under the environmental condition in the high ground to the wavelength of lambda= 0.248318 micrometers (the 2nd wave). However, the distortion aberration view which the distortion aberration view shown in drawing 6 (c) is a thing at the time of setting to nairL=1.0002920 (refractive index of the air in lowlands with an altitude of 50m) the refractive index of the air of the lens data shown in Table 2, and is shown in drawing 5 (d) is a thing at the time of setting to nairH=1.0002617 (refractive index of the air in high ground with an altitude of 1000m) the refractive index of the air of the lens data shown in Table 2.

[0041] In addition, although the distortion aberration view shown in the spherical-aberration view and drawing 6 (d) which are shown in drawing 5 (d) is mentioned later, it sets the refractive index of the air of the lens data shown in Table 2 to nairL=1.0002920 (refractive index of the air in lowlands with an altitude of 50m shown by the above-mentioned (12) formula), and agrees in the spherical-aberration

curve and distortion aberration curve in the case where the wavelength of light is changed into lambda= 0.248318 micrometers (the 2nd wave)
[0042] If the value of aberration offset (for example, lens interval of L2 -L29 (air interval)) of a projection optical system is calculated as shown in the above table 2, it will shift to the following step 4.
[Step 4] At Step 4, the setting position of each lens which constitutes a projection optical system etc. is readjusted based on the value of aberration offset (for example, lens interval of L2 -L29 shown in Table 2 (air interval)) of the projection optical system called for at the 2nd sub step of the above-mentioned step 3. And if the process of this readjustment is completed, the projection optical system by which difference adjustment was carried out will be attached in the aligner main part shown in drawing 1 , and will shift to the adjustment process of the output wavelength of the following step 5 after that.
[Step 5] At Step 5, in order to reproduce the environmental condition in high ground in false under the environmental condition in lowlands on the occasion of inspection (evaluation) of a projection optical system, the wavelength (the 1st wave) of a checking light first supplied from the light source 11 for the exposure for inspecting a projection optical system 14 (evaluation) is set up and adjusted to predetermined wavelength (the 2nd wave).
[0043] At Step 5, it precedes adjusting the wavelength of the light supplied from the light source 11, and the 2nd wave (wavelength which is different in the 2nd wave) as setting wavelength or adjustment wavelength is computed first. That is, at Step 5, it has the 1st sub step which computes the amount of adjustments of the wavelength of a checking light supplied from the light source 11 (or value of the wavelength of a checking light), and the 2nd sub step which adjusts wavelength of a checking light supplied from the light source 11 (or wavelength of a checking light the 2nd predetermined wave setup).

[0044] Here, the example of the 5th step is explained based on the projection optical system 14 of drawing 4 shown in Table 1 and 2.
(The 1st sub step) As shown in Table 1 and 2, as shown in Table 1 and 2, synthetic quartz is used as a refractility optical member which constitutes the projection optical system 14 of drawing 4 .
[0045] Now, if the relative index of refraction nrel of the synthetic quartz to 0.2484 micrometers (the 1st wave) light shall be 1.5083900, the absolute refractive index nabs1 of the synthetic quartz will become like (13) formulas of the following [relation / between the above-mentioned (7) formula, (11) formulas, and (12) formulas].
(13) The absolute refractive index nabs2 of the synthetic quartz to the light of the 2nd wave will become like the following (14) formulas at it, if the value of an above-mentioned (11) formula - (13) formula is substituted for nabs1=nrel xnairL=1.5088305 pan at an above-mentioned (7) ceremony.
(14) nabs2=nairLxnabs1/nairH=1.5088762 and wavelength shall have the relation of the following (15) formulas in distribution of the synthetic quartz near lambda= 0.2484 micrometer.
(15) delta n/delta lambda=-56x10-2 (micrometer-1)
Then, since it is deltan=nabs2-nabs1, amount of change deltalambda of the wavelength of the light source is [about] from the relation of an above-mentioned (13) formula - (15) formula. -It is set to 8.2x10 to 5 micrometer.
[0046] Therefore, at the point whose altitude is 50m, the evaluation of the optical-character ability of a projection optical system 14 of the altitude is attained under the environment of the atmospheric pressure equivalent to 1000m by changing the wavelength of the light source into 0.248318 micrometers (the 2nd wave) from 0.2484 micrometers (the 1st wave).
(The 2nd sub step) At the 2nd sub step of Step 5, the output wavelength of the light source 11 is adjusted so that the output wavelength of the light source 11 shown in drawing 1 may be set to lambda= 0.248318 micrometers (the 2nd wave) based on the computed wavelength variation (deltalambda=-8.2x10-5micrometer).
[0047] That is, as shown in drawing 2 , the information about the 2nd wave (lambda= 0.248318 micrometers) as setting wavelength called for at the 1st sub step of Step 5 is inputted into the amount calculation section 26 of adjustments through the input sections 28, such as a console. And the amount calculation section 26 of adjustments computes the amount of wavelength adjustments about a

wavelength-adjustment means (prism 22 and reflected type diffraction grating 21) based on the measurement information from the wavelength monitor 24, and the input from the input section 28. Then, the amount calculation section 26 of adjustments makes a wavelength-adjustment means (prism 22 and reflected type diffraction grating 21) drive through a mechanical component 27. It is adjusted so that the output wavelength of the light finally oscillated from the excimer laser oscillation section 23 (light source 1) by this may turn into the 2nd wave (lambda= 0.248318 micrometers). If the adjustment process of the output wavelength in this step 5 is completed, it will shift to the inspection process (evaluation process) of the following step 6.

[Step 6] At Step 6, in order that the projection optical system 14 to which the aberration offset for high grounds was given by readjustment of the above-mentioned step 4 may check whether optical-character ability predetermined by the basis of the 2nd wave (lambda= 0.248318 micrometers) is filled, optical-character ability of a projection optical system 14 is inspected by the same technique as the above-mentioned step 2 (evaluation). The optical-character ability of a projection optical system 14 is estimated by the technique of trial exposure for example. And it is amended as spherical aberration shows the projection optical system 14 adjusted, for example as shown in Table 2 to drawing 5 (d), and it inspects whether as the distortion aberration of a projection optical system 14 shows drawing 6 (d), it is amended and is (evaluation).

[0048] In addition, although the aberration view shown in drawing 5 (d) and drawing 6 (d) shows the curve of the spherical aberration over the 1st wave (lambda= 0.2484 micrometers) and distortion aberration in a basis of the environmental condition (the refractive index nairH of air is 1.0002617) in high ground If the optical-character ability (image formation performance) of the projection optical system 14 to which the aberration offset for high grounds was given is good, the spherical aberration and distortion aberration of a projection optical system 14 which are inspected in Step 6 will agree with the aberration curve shown in drawing 5 (d) and drawing 6 (d).

[0049] Here, as a result of evaluating the optical-character ability of a projection optical system 14, when the optical-character ability of a projection optical system 14 is not filling predetermined optical-character ability, it shifts to the readjustment process of the following step 7, and adjustment of a projection optical system 14 is performed again. Moreover, when the optical-character ability of a projection optical system 14 is filling predetermined optical-character ability, it shifts to the wavelength reconfiguration process to the criteria wavelength of the following step 6.

[Step 7] At Step 7, when it is judged that the optical-character ability of a projection optical system 14 is not filling predetermined optical-character ability in the above step 6, the projection optical system 14 setting up was finished by many optical members (a lens, lens attachment component, etc.) by the same technique as the above-mentioned step 2 is readjusted. That is, at this step 7, in order to fully pull out the performance of a projection optical system 14 in which the aberration offset for high grounds was given, the interval between the optical faculty material which constitutes a projection optical system 13 (for example, interval between lenses) is changed, or a projection optical system 14 is readjusted by making the variation rate of the optical member which constitutes a projection optical system 14 carry out in the direction which intersects perpendicularly with an inclination or an optical axis etc. If the readjustment process of this step 7 is completed, it will return to the above-mentioned step 6 again, and optical-character ability of a projection optical system 14 will be rechecked (reevaluation).

[Step 8] After it is judged that the optical-character ability of a projection optical system 14 is not filling predetermined optical-character ability in the above step 6, at Step 8, the wavelength outputted from the light source for exposure is reset as the exposure wavelength (criteria wavelength) actually used at high ground.

[0050] When a projection optical system 14 is attached in the aligner shown in drawing 1 in the above steps 5 and 6 here, at Step 8, the light source 1 of an aligner is returned to the criteria wavelength (the 1st wave) of an actual busy condition. As the technique of returning the light source 1 of an aligner to an actual busy condition is first shown in drawing 2 , the information about the 1st wave (lambda= 0.2484 micrometers) as setting wavelength (criteria wavelength) is inputted into the amount calculation section 26 of adjustments through the input sections 28, such as a console. And the amount calculation section

26 of adjustments computes the amount of wavelength adjustments about a wavelength-adjustment means (prism 22 and reflected type diffraction grating 21) based on the measurement information from the wavelength monitor 24, and the input from the input section 28. Then, the amount calculation section 26 of adjustments makes a wavelength-adjustment means (prism 22 and reflected type diffraction grating 21) drive through a mechanical component 27. It is adjusted so that the output wavelength of the light finally oscillated from the excimer laser oscillation section 23 (light source 1) by this may turn into the 1st wave (lambda= 0.2484 micrometers).
[0051] As mentioned above, an aligner is completed by passing through Steps 1-8. For this reason, the performance under the environment of the lowlands which adjusted and evaluated the projection optical system 14 of an aligner though this completed aligner was transported and installed to high ground can reappear under the environment of high ground. Moreover, an aligner may perform the process of Step 8 in the place (for example, high ground) actually installed and used. In this case, between Step 7 and Step 8, in order to make transportation to the high ground of an aligner easy moreover, without spoiling the performance of an aligner, it is desirable to once decompose an aligner into each unit (the light source 11, the lighting optical system 12, projection-optical-system 14 grade) of every, and to assemble an aligner at high ground.
[0052] The aligner which passed through the above steps 1-8 is transported and installed to high ground as it is (or transporting to high ground and assembling an aligner at high ground, after once decomposing the aligner which passed through Steps 1-8 for every unit installation). Then, a good semiconductor device can be manufactured also at high ground by performing an exposure process by the aligner shown in drawing 1 . The exposure process at this time lays photosensitive substrates (wafer etc.) on a non-illustrated substrate stage, and sets the photosensitive substrate 15 as the image surface of a projection optical system 14 while it lays the mask 13 for exposure on a non-illustrated mask stage and sets the mask 13 for exposure as the body side of a projection optical system 14 first, as shown in drawing 1 . Next, the mask 13 for exposure is illuminated for the light from the light source 1 through the lighting optical system 12, and the circuit pattern image of the mask 13 for exposure is projected on the photosensitive substrate 15 through a projection optical system 14. By this, the pattern image of the good mask 13 can be imprinted to the photosensitive substrate 15 under the environment of high ground. Therefore, a good semiconductor device can be manufactured under the environment of high ground.
[0053] By the way, it faced inspecting [set above and] or evaluating the optical-character ability of a projection optical system, and the example using the light outputted from light source 11 self for exposure prepared in the exposure main part shown in drawing 1 was explained, referring to drawing 3 . However, the test equipment with the same composition as the aligner shown in drawing 1 and drawing 2 only for inspection can be used for this invention, and it can also inspect or evaluate the optical-character ability of a projection optical system. In this case, the work habits which come out are shown in the flow chart of drawing 7 .
[0054] Since Steps 11-16 shown in drawing 7 are the same as Steps 1-6 shown in drawing 3 , respectively, explanation is omitted. When the optical-character ability of a projection optical system is judged to be good as a result of the inspection using a checking light of the 2nd wave outputted from the light source of the test equipment in Step 16 shown in drawing 7 , it shifts to Step 18. And at Step 18, the projection optical system which passed through the above-mentioned step 16 is attached in an aligner main part with the light source set up so that the exposure wavelength as the 1st wave might be outputted, and an aligner completes it.
[0055] At this step 18, the aligner main part shown in the projection optical system 14 and drawing 1 which passed through the above step 16 may be transported to high ground in the state where it separated into each unit (the light source 11, the lighting optical system 12, projection-optical-system 14 grade) of every, and these units may be assembled at high ground, and it may install, and an aligner may be completed. As mentioned above, the aligner which passed through the above steps 11-18 can be transported and installed to high ground, and a good semiconductor device can be manufactured also at high ground by performing an exposure process by the aligner after that.
[0056] In addition, although the example shown in drawing 7 described the example which makes the

wavelength of the light source change into the 2nd wave of the 2nd checking from the 1st wave as exposure wavelength (criteria wavelength) of the 1st checking using one test equipment (change), this invention is not restricted to this technique. For example, the wavelength-adjustment process (wavelength change process) of Step 16 shown in drawing 7 can be skipped by using two test equipment. That is, the 1st inspection process of the above-mentioned step 12 is performed using the 1st test equipment equipped with the light source which supplies the light of the 1st wave as exposure wavelength (criteria wavelength) of the 1st checking. The 2nd test equipment equipped with the light source which supplies a predetermined light of the 2nd checking of the 2nd wave set up based on the difference in in the high ground and the environmental condition for which the environmental condition of the lowlands by which a projection optical system is inspected or manufactured, and a projection optical system are actually used is used. the 2nd inspection process of the above-mentioned step 16 You may adopt the technique to perform.

[0057] Moreover, although its attention was paid to atmospheric pressure in each above example as a difference in the environmental condition of the place which the aligner containing a projection system adjusts and evaluates, and the place which actually installs and uses the aligner containing a projection system, it cannot be overemphasized that it may not restrict to this and environmental differences, such as a temperature gradient and a humidity difference, may be taken into consideration. Thus, after according to this invention performing adjustment of optical system and evaluation and attaining a desired performance, In order that equipments, such as an aligner, may give the aberration offset corresponding to the environment of the place actually installed and used and may next check beforehand the optical-character ability of the optical system in high ground By changing the wavelength of the light source of equipments, such as an aligner, it becomes possible to adjust and evaluate the optical-character ability of optical system with a sufficient precision.

[0058] Moreover, this invention cannot be overemphasized by that this reverse case is sufficient although the above example showed the example with the altitude higher than the point which performs adjustment and evaluation of optical system in the point which actually installs and uses equipments, such as an aligner. "In addition, the claims 1, 3, 4, 6, 7, 10, 11, and 12 of the above claim and 13 grades It is based on the difference between the 1st environmental condition and the 2nd environmental condition. the publication of the purport " -- ", according to change (difference) of the refractive index of the gas (medium) which surrounds the optical system (projection optical system) which originates in the difference between the 1st environmental condition and the 2nd environmental condition, and is produced, it can also consider as the publication of the purport "

[0059]

[Effect of the Invention] As mentioned above, in the environment same in false as the bottom of the environment in the place where the optical system is actually installed or used though there is a difference in the environmental condition of the place which conducts adjustment and inspection of optical system, and the place where the optical system is actually installed or used according to this invention, about the optical-character ability of the optical system, if adjustment and inspection are made simple under the environment to perform, ** will become possible. Therefore, it can also set in the place which conducts adjustment and inspection of optical system, and the optical-character ability of the same optical system as the place where optical system is actually installed or used can be adjusted and inspected with a sufficient precision. By this, the optical system which has good optical-character ability can be manufactured.

[Translation done.]

* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing showing the rough composition of an aligner.
[Drawing 2] It is drawing showing the structure of the excimer laser used as the light source of an aligner shown in drawing 1 .
[Drawing 3] It is drawing for explaining the procedure about one technique by this invention.
[Drawing 4] It is the lens block diagram showing one example of the projection optical system in the aligner shown in drawing 1 .
[Drawing 5] It is drawing showing the situation of the spherical aberration of a projection optical system shown in drawing 4 .
[Drawing 6] It is drawing showing the situation of the distortion aberration of a projection optical system shown in drawing 4 .
[Drawing 7] It is drawing for explaining the procedure about the technique of another ** by this invention.
[Description of Notations]
11 ..... Light source
12 ..... Lighting optical system
13 R ..... Reticle
14 ..... Projection optical system
15 W ..... Substrate (wafer)
21 ..... Reflected type diffraction grating
22 ..... Prism
23 ..... Excimer laser oscillation section (laser chamber)
24 ..... Wavelength monitor
25 ..... One-way mirror
26 ..... The amount calculation section of adjustments
27 ..... Mechanical component
28 ..... Input section

[Translation done.]

* NOTICES *

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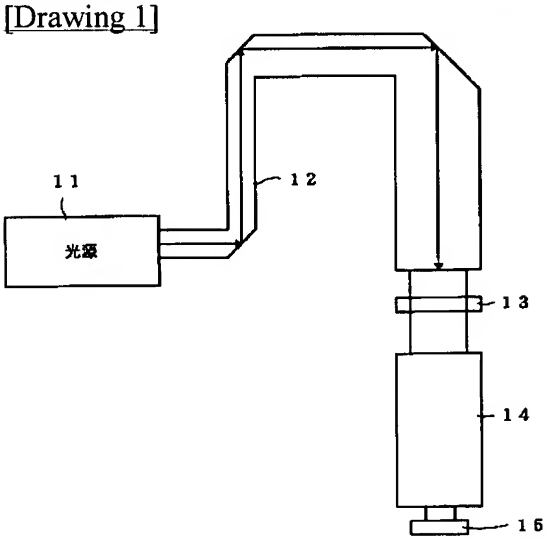
damages caused by the use of this translation.

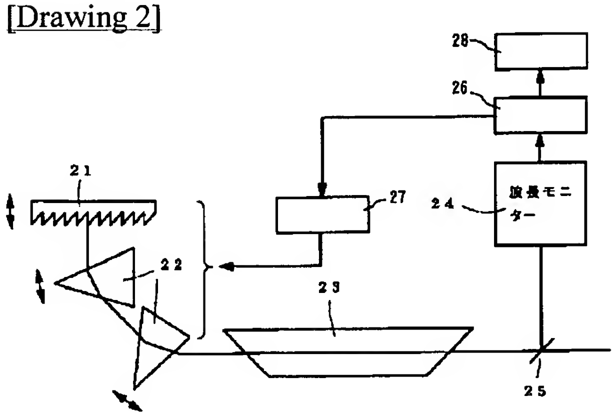
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

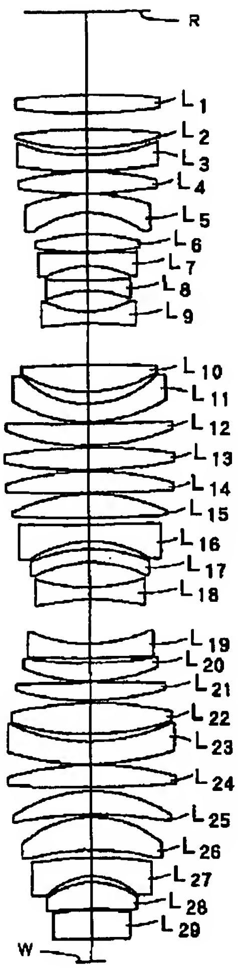
[Drawing 1]



[Drawing 2]



[Drawing 4]


R
L1
L2
L3
L4
L5
L6
L7
L8
L9
L10
L11
L12
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L16
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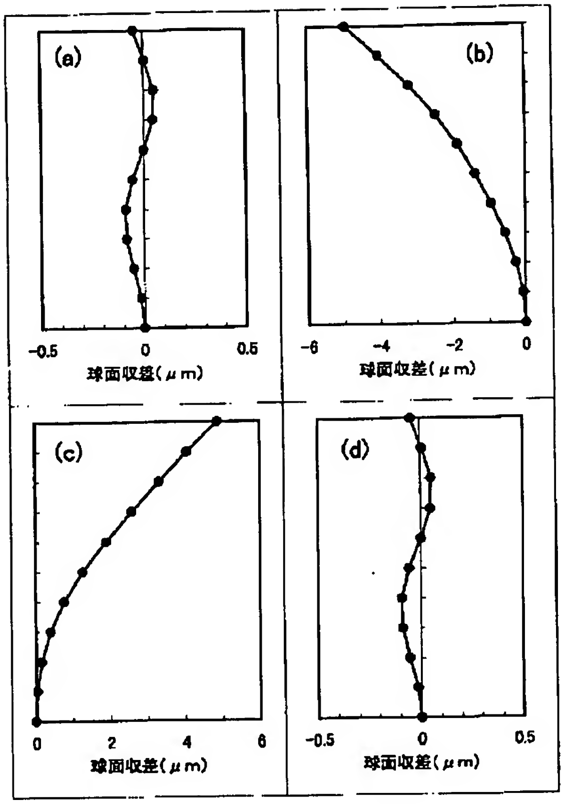
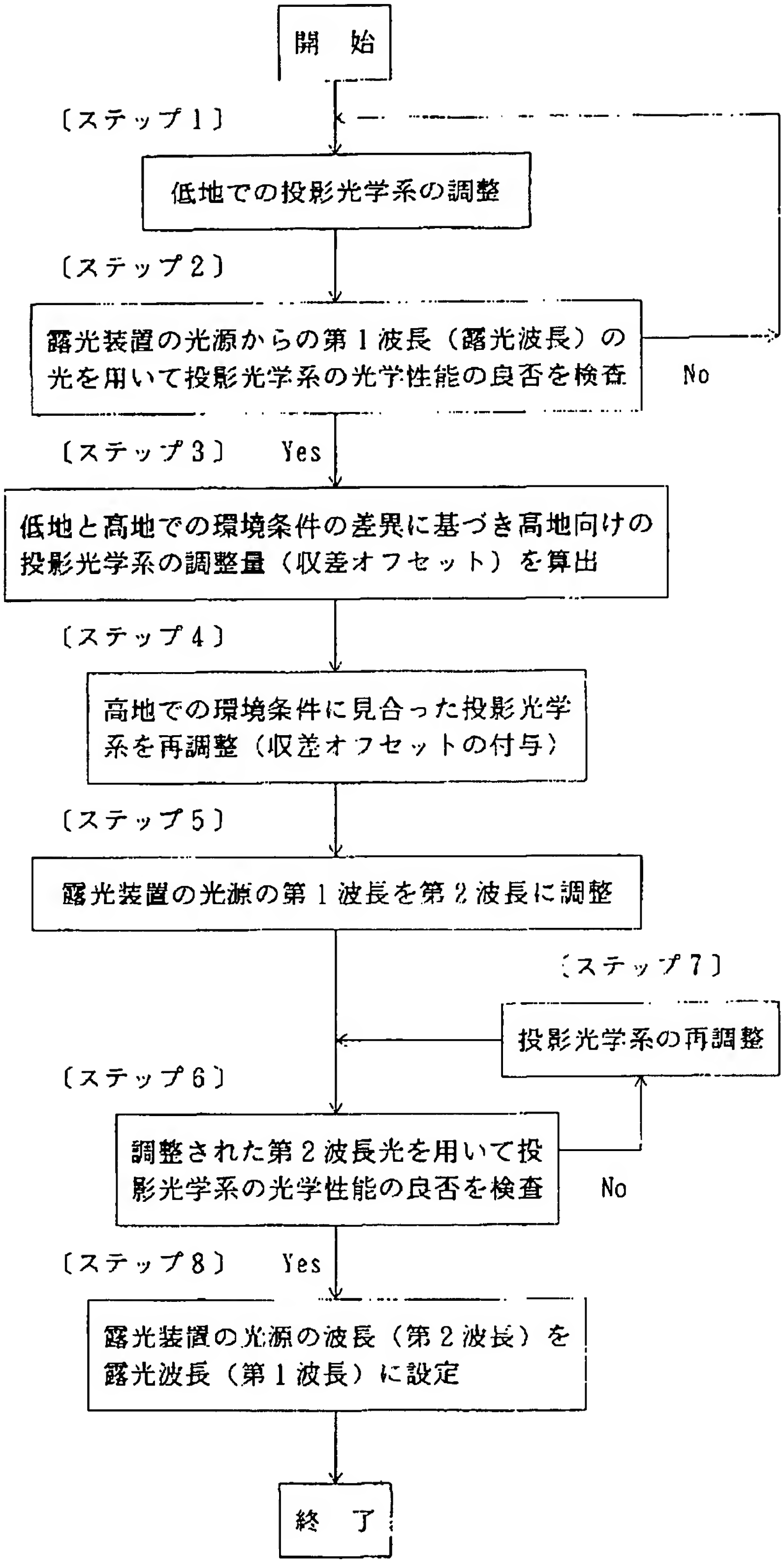
L28
L29
W

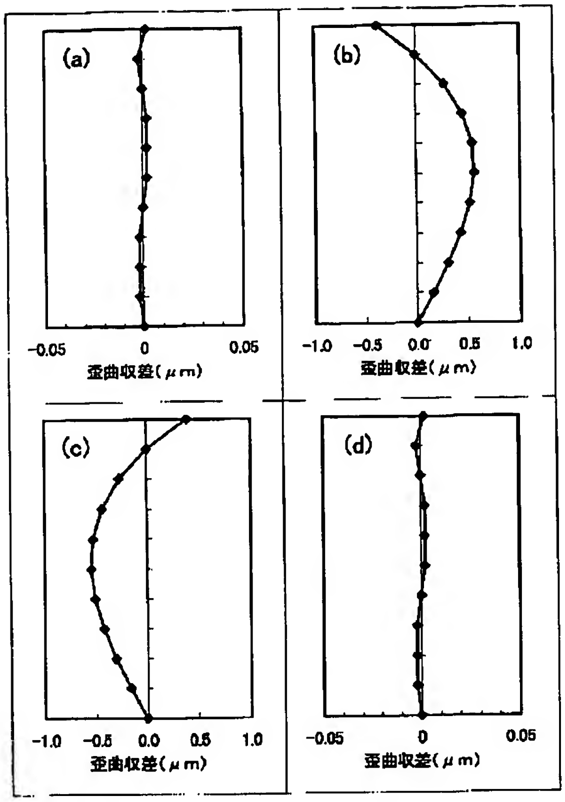
[Drawing 5]



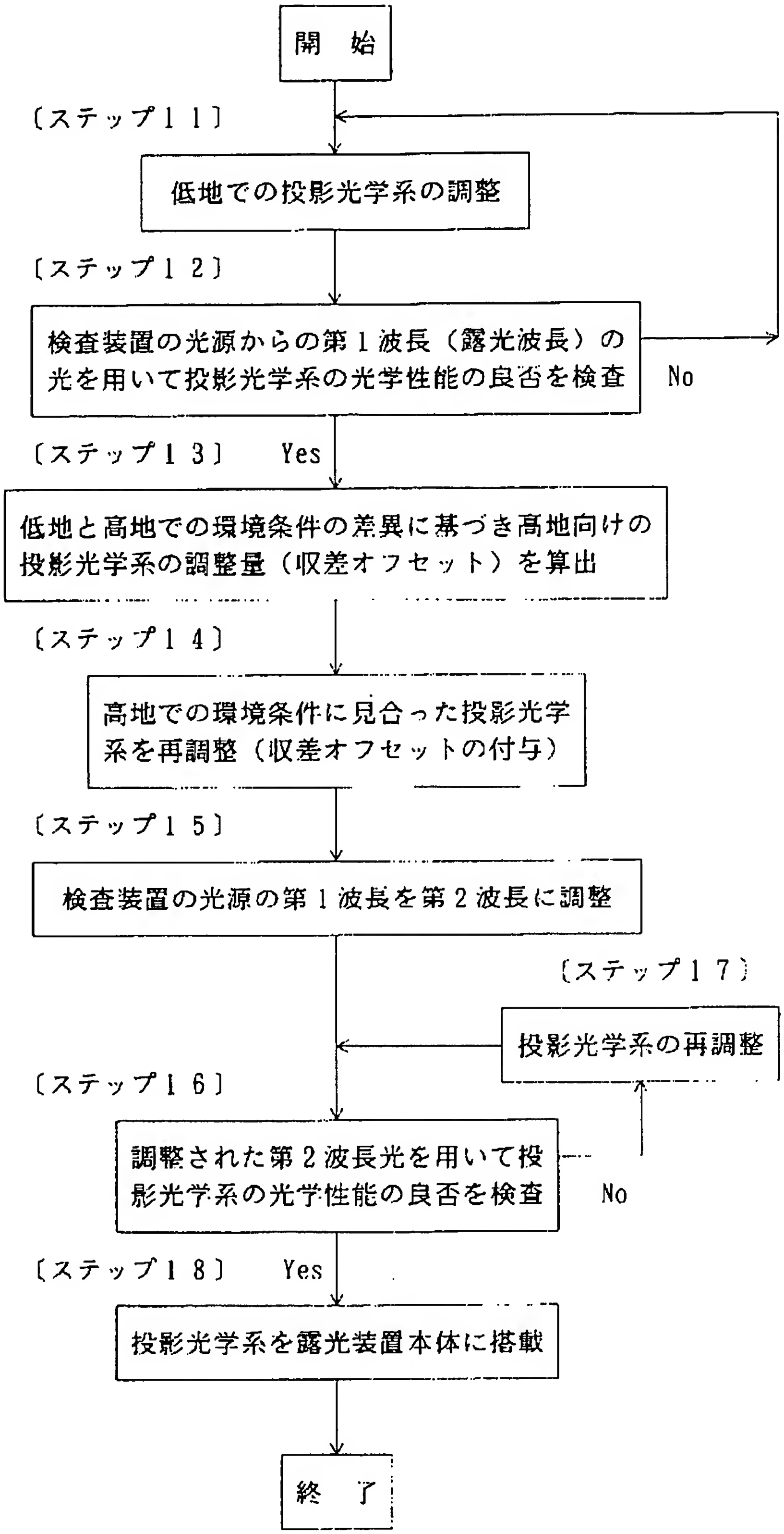
[Drawing 3]


開　始
〔ステップ1〕
低地での投影光学系の調整
〔ステップ2〕
露光装置の光源からの第1波長（露光波長）の光を用いて投影光学系の光学性能の良否を検査
No
〔ステップ3〕
Yes
低地と高地での環境条件の差異に基づき高地向けの投影光学系の調整量（収差オフセット）を算出
〔ステップ4〕
高地での環境条件に見合った投影光学系を再調整（収差オフセットの付与）
〔ステップ5〕
露光装置の光源の第1波長を第2波長に調整
〔ステップ7〕
投影光学系の再調整
〔ステップ6〕
調整された第2波長光を用いて投影光学系の光学性能の良否を検査
No
〔ステップ8〕
Yes
露光装置の光源の波長（第2波長）を露光波長（第1波長）に設定
終　了

[Drawing 6]


(a)
-0.05
0
0.05
歪曲収差(μm)
(b)
-1.0
-0.5
0.0
0.5
1.0
歪曲収差(μm)
(c)
-1.0
-0.5
0.0
0.5
1.0
歪曲収差(μm)
(d)
-0.05
0
0.05
歪曲収差(μm)

[Drawing 7]



[Translation done.]

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Ｈ０１Ｌ　21/027		Ｈ０１Ｌ　21/30	５１５Ｄ
			５１６Ａ

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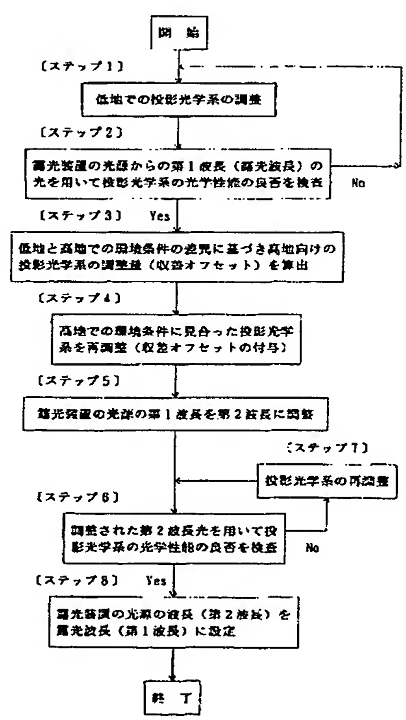
(54)【発明の名称】　光学系の検査方法、光学系の製造方法及び露光装置の製造方法

(57)【要約】

【目的】本発明は、露光装置等の光学装置が実際に設置及び使用される環境条件とは異なる環境条件下でも投影光学系等の光学系の結像性能を、装置が設置及び使用される環境条件と同じになるように調整及び評価でき得る光学系の検査方法、その検査方法を用いた光学系及び露光装置の製造方法を提供する。

【構成】所定の波長を持つ光を光学系へ導く導光工程と、前記光学系の調整場所での環境条件と前記光学系の使用場所での環境条件の差異に基づき前記光学系に入射する前記光の波長を調整する波長調整工程とを有する光学系の検査方法。



【特許請求の範囲】

【請求項１】光学系の光学性能が検査される第１環境条件と前記光学系が使用される第２環境条件との差異に基づき、前記光学系の光学性能を検査するための検査光の波長を調整する波長調整工程と、
前記波長調整工程によって調整された波長を持つ検査光を用いて前記光学系の光学性能を検査する検査工程を有することを特徴とする光学系の検査方法。

【請求項２】第１波長を持つ第１検査光を用いて光学系の光学性能を第１環境条件のもとで検査する第１検査工程と、
前記光学系が使用される第２環境条件のもとで前記光学系の光学性能が最適となるように前記光学系に関する調整量を算出する調整量算出工程と、
前記調整量算出工程にて得られた前記光学系に関する調整量に基づいて前記光学系を調整する光学調整工程と、
前記第１波長の検査光とは異なる所定の第２波長を持つ第２検査光を用いて、前記光学調整工程によって調整された前記光学系の光学性能を前記第１環境条件のもとで検査する第２検査工程とを有することを特徴とする光学系の製造方法。

【請求項３】光学系の光学性能が検査される第１環境条件と前記光学系が使用される第２環境条件との差異に基づいて、第２環境条件のもとで前記光学系の光学性能が最適となるように前記光学系に関する調整量を算出する調整量算出工程と、
前記調整量算出工程にて得られた前記光学系に関する調整量に基づいて前記光学系を調整する光学調整工程と、
前記光学系の光学性能を検査するための検査用の光の波長を調整する波長調整工程を、
前記波長調整工程によって調整された波長を持つ検査用の光を用いて前記光学調整工程によって調整された前記光学系の光学特性を前記第１環境条件のもとで検査する検査工程とを有することを特徴とする光学系の製造方法。

【請求項４】前記波長調整工程は、第１環境条件と前記第２環境条件との差異に基づいて前記検査用の光の波長を求める波長算出工程を含むことを特徴とする請求項３に記載の光学系の製造方法。

【請求項５】前記光学系は、マスク上に形成される所定のパターンの像を感光性基板に投影する投影光学系であることを特徴とする請求項３又は請求項４に記載の光学系の製造方法。

【請求項６】第１環境条件のもとで光学系を調整する第１調整工程と、前記第１調整工程によって調整された前記光学系の光学性能を所定の波長を持つ検査光を用いて前記第１環境条件のもとで検査する第１検査工程と、
前記第１調整工程及び前記第１検査工程が実行される第１環境条件と前記光学系が使用される第２環境条件との差異に基づいて、前記第２環境条件のもとで前記光学系の光学性能が最適となるように前記光学系に関する調整量を算出する調整量算出工程と、
前記調整量算出工程にて得られた前記光学系に関する調整量に基づいて前記光学系を調整する第２調整工程と、
前記検査光の波長を調整する波長調整工程と、
前記波長調整工程によって調整された検査光を用いて前記第２調整工程によって調整された前記光学系の光学特性を前記第１環境条件のもとで再検査する第２検査工程とを有することを特徴とする光学系の製造方法。

【請求項７】前記波長調整工程は、前記第１環境条件と前記第２環境条件との差異に基づいて、前記光学系の光学性能を再検査するための検査光の波長を求める波長算出工程を含むことを特徴とする請求項６に記載の光学系の製造方法。

【請求項８】前記光学系は、マスク上に形成される所定のパターンの像を感光性基板に投影する投影光学系であることを特徴とする請求項６又は請求項７に記載の光学系の製造方法。

【請求項９】請求項８に記載の光学系の製造方法によって製造された光学系を提供する工程と、
前記光学系の物体面に前記マスクを設定するマスク設定工程と、
前記光学系の像面に前記感光性基板を設定する基板設定工程と、
前記第１検査工程で用いた検査光または前記第１検査工程で用いた検査光と同じ波長を持つ光を露光用の光として用いて前記マスクを照明する照明工程と、
前記投影光学系を介して前記マスクのパターン像を前記感光性基板に投影する投影工程とを含むことを特徴とする露光方法。

【請求項１０】所定のパターンが形成されたマスクを照明するために、所定の基準波長を持つ光を出力する光源と、前記マスクのパターンの像を感光性基板に投影する投影光学系とを備えた露光装置の製造方法において、
前記露光装置が製造される第１環境条件と前記露光装置が使用される第２環境条件との差異に基づいて、第２環境条件のもとで前記投影光学系の光学性能が最適となるように前記投影光学系に関する調整量を算出する調整量算出工程と、
前記調整量算出工程にて得られた前記投影光学系に関する調整量に基づいて前記投影光学系を調整する光学調整工程と、
前記光源から出力される光の基準波長を該基準波長とは異なる検査用の光の波長に調整する波長調整工程と、
前記波長調整工程によって調整された波長を持つ検査用の光を用いて前記調整工程によって調整された前記投影光学系の光学特性を前記第１環境条件のもとで検査する検査工程とを有することを特徴とする露光装置の製造方法。

【請求項１１】前記波長調整工程は、前記第１環境条件

と前記第２環境条件との差異に基づき、前記投影光学系の光学性能を検査するための検査用の光の波長を求める波長算出工程とを含むことを特徴とする請求項１０に記載の露光装置の製造方法。

【請求項１２】所定のパターンが形成されたマスクを照明するために、所定の基準波長を持つ光を出力する光源と、前記マスクのパターンの像を感光性基板に投影する投影光学系とを備えた露光装置の製造方法において、

第１環境条件のもとで前記投影光学系を調整する第１調整工程と、

前記第１調整工程によって調整された前記投影光学系の光学性能を前記光源から出力される前記基準波長を持つ光を用いて前記第１環境条件のもとで検査する第１検査工程と、

前記第１調整工程及び前記第１検査工程が実行される第１環境条件と前記露光装置が使用される第２環境条件との差異に基づいて、第２環境条件のもとで前記投影光学系の光学性能が最適となるように前記投影光学系に関する調整量を算出する調整量算出工程と、

前記調整量算出工程にて得られた前記投影光学系に関する調整量に基づいて前記投影光学系を調整する第２調整工程と、

前記光源から出力される光の基準波長を第２検査用の光の波長に調整する波長調整工程と、

前記波長調整工程によって調整された波長を持つ前記第２検査用の光を用いて前記２調整工程によって調整された前記投影光学系の光学特性を前記第１環境条件のもとで検査する第２検査工程とを有することを特徴とする露光装置の製造方法。

【請求項１３】前記波長調整工程は、前記第１環境条件と前記第２環境条件との差異に基づき、前記投影光学系の光学性能を再検査するための前記第２検査用の光の波長を求める波長算出工程を含むことを特徴とする請求項１２に記載の露光装置の製造方法。

【請求項１４】前記露光装置が使用される前記第２環境条件のもとに設置される迄に、前記光源から出力される光の波長を前記基準波長に設定する基準波長設定工程をさらに有することを特徴とする請求項１０乃至請求項１３のいずれか１項に記載の露光装置の製造方法。

【請求項１５】請求項１４に記載の露光装置の製造方法によって製造された露光装置を提供する工程と、

前記光源からの基準波長によって前記マスクを照明する照明工程と、

前記投影光学系を介して前記マスクのパターン像を前記感光性基板に投影する投影工程とを含むことを特徴とする露光方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、光学系の評価方法に関するものであり、特に、好ましくは半導体素子や液晶表示素子を光リソグラフィー工程によって製造する露光装置における投影光学系の評価方法に関するものである。

【０００２】

【従来の技術】半導体素子、液晶表示素子等の素子を製造するために、所定のパターンが形成された投影原版としてのマスクを、投影光学系を介して感光性基板上に投影露光する露光装置が用いられている。このような露光装置の投影光学系としては、露光波長の光に対して透過性の光学特性を持つ屈折性の光学素子等のレンズで構成される屈折型の投影光学系、あるいは屈折性の光学素子等のレンズと反射性の光学素子としてのミラーとを組み合わせて構成される反射屈折型の投影光学系が用いられている。

【０００３】他方、近年においては、半導体素子、液晶表示素子等に代表される素子の集積度が高まり、感光性基板上に転写されるパターンも微細化の一途をたどっている。そして、マスクのパターンを感光性基板に良好に転写し得る露光装置、さらにはより高い集積度を持つ半導体素子を始めとした各種の素子を製造するための露光装置を実現するためには、露光装置中の投影光学系においてより高い解像力を持つ極めて高い光学性能が要求される。

【０００４】より高い解像力を達成するために、投影光学系の開口数（ＮＡ）が大きくなっているのと同時に、露光光を供給する光源もｇ線（436nm)やｉ線（365nm)を発光する従来の超高圧水銀ランプから、より波長の短いエキシマレーザ等が用いられ始められている。これらの露光装置が設置されて実際に使用される場所は、露光装置の投影光学系の調整及び評価が行われた環境条件と必ずしも同じとは限らない。例えば、露光装置が設置されて実際に使用される場所は、露光装置の投影光学系の調整及び評価が行われた標高と比べて、はるかに標高が高く、平均気圧の低い場所となるケースも多い。

【０００５】

【発明が解決しようとする課題】一般的に、標高が変化する大気圧が変化し、それに伴い空気の屈折率が変化する。そして、空気の屈折率が変化すると、レンズ等の屈折性の光学素子等においては、屈折面での光線の屈折角が変化し、その結果、光学系の結像性能が変化する。

【０００６】従来においては、露光装置の投影光学系の調整、評価を行う標高（以下、低地と呼ぶ。）と露光装置が実際に設置及び使用される標高（以下、高地と呼ぶ。）が異なる場合には、一旦、低地において調整等によって投影光学系を所望の結像性能にする。その後、例えば投影光学系のレンズ間隔を変更して、露光装置を高地に移動及び設置した状態において、投影光学系の所望の結像性能が再現できるように意図的に投影光学系の結像性能を変化させている。

【０００７】しかしながら、投影光学系において異なる

標高向けの収差オフセットを加えた場合には、投影光学系の結像性能が悪化し、低地において投影光学系の結像性能の正確な評価が困難となる。このため、露光装置が実際に設置及び使用される場所での投影光学系の光学性能を予め低地において確認するためには、露光装置全体が収納できる気圧可変チャンバー等の大掛かりな設備と時間が必要となる。

【０００８】そこで、本発明は、以上の課題に鑑みてなされたものであり、露光装置等の光学装置が実際に設置及び使用される環境条件とは異なる環境条件下でも投影光学系等の光学系の結像性能を、装置が設置及び使用される環境条件と同じになるように調整及び評価でき得る光学系の検査方法、その検査方法を用いた光学系及び露光装置の製造方法を提供することを目的としている。

【０００９】

【発明を解決するための手段】以上の目的を達成するために、請求項１に係る発明では、光学系の光学性能が検査される第１環境条件と前記光学系が使用される第２環境条件との差異に基づき、前記光学系の光学性能を検査するための検査光の波長を調整する波長調整工程と、前記波長調整工程によって調整された波長を持つ検査光を用いて前記光学系の光学性能を検査する検査工程を有する光学系の検査方法を提供するものである。

【００１０】請求項２に係る発明では、第１波長を持つ第１検査光を用いて光学系の光学性能を第１環境条件のもとで検査する第１検査工程と、前記光学系が使用される第２環境条件のもとで前記光学系の光学性能が最適となるように前記光学系に関する調整量を算出する調整量算出工程と、前記調整量算出工程にて得られた前記光学系に関する調整量に基づいて前記光学系を調整する光学調整工程と、前記第１波長の検査光とは異なる所定の第２波長を持つ第２検査光を用いて、前記光学調整工程によって調整された前記光学系の光学性能を前記第１環境条件のもとで検査する第２検査工程とを有する光学系の製造方法を提供するものである。

【００１１】請求項３に係る発明では、光学系の光学性能が検査される第１環境条件と前記光学系が使用される第２環境条件との差異に基づいて、第２環境条件のもとで前記光学系の光学性能が最適となるように前記光学系に関する調整量を算出する調整量算出工程と、前記調整量算出工程にて得られた前記光学系に関する調整量に基づいて前記光学系を調整する光学調整工程と、前記光学系の光学性能を検査するための検査用の光の波長を調整する波長調整工程を、前記波長調整工程によって調整された波長を持つ検査用の光を用いて前記光学調整工程によって調整された前記光学系の光学特性を前記第１環境条件のもとで検査する検査工程とを有する光学系の製造方法を提供するものである。

【００１２】請求項４に係る発明では、上記請求項３の発明に基づき、前記波長調整工程は、第１環境条件と前記第２環境条件との差異に基づいて前記検査用の光の波長を求める波長算出工程を含む光学系の製造方法を提供するものである。請求項５に係る発明では、上記請求項３及び請求項４の発明に基づき、前記光学系がマスク上に形成される所定のパターンの像を感光性基板に投影する投影光学系である光学系の製造方法を提供するものである。

【００１３】請求項６に係る発明では、第１環境条件のもとで光学系を調整する第１調整工程と、前記第１調整工程によって調整された前記光学系の光学性能を所定の波長を持つ検査光を用いて前記第１環境条件のもとで検査する第１検査工程と、前記第１調整工程及び前記第１検査工程が実行される第１環境条件と前記光学系が使用される第２環境条件との差異に基づいて、前記第２環境条件のもとで前記光学系の光学性能が最適となるように前記光学系に関する調整量を算出する調整量算出工程と、前記調整量算出工程にて得られた前記光学系に関する調整量に基づいて前記光学系を調整する第２調整工程と、前記検査光の波長を調整する波長調整工程と、前記波長調整工程によって調整された検査光を用いて前記第２調整工程によって調整された前記光学系の光学特性を前記第１環境条件のもとで再検査する第２検査工程とを有する光学系の製造方法を提供するものである。

【００１４】請求項７に係る発明では、請求項６の発明に基づき、前記波長調整工程は、前記第１環境条件と前記第２環境条件との差異に基づいて、前記光学系の光学性能を再検査するための検査光の波長を求める波長算出工程を含む光学系の製造方法を提供するものである。請求項８に係る発明では、上記請求項６及び請求項７の発明に基づき、前記光学系は、マスク上に形成される所定のパターンの像を感光性基板に投影する投影光学系である光学系の製造方法を提供するものである。

【００１５】請求項９に係る発明では、請求項８に記載の光学系の製造方法によって製造された光学系を提供する工程と、前記光学系の物体面に前記マスクを設定するマスク設定工程と、前記光学系の像面に前記感光性基板を設定する基板設定工程と、前記第１検査工程で用いた検査光または前記第１検査工程で用いた検査光と同じ波長を持つ光を露光用の光として用いて前記マスクを照明する照明工程と、前記投影光学系を介して前記マスクのパターン像を前記感光性基板に投影する投影工程とを含む露光方法を提供するものである。

【００１６】請求項１０に係る発明では、所定のパターンが形成されたマスクを照明するために、所定の基準波長を持つ光を出力する光源と、前記マスクのパターンの像を感光性基板に投影する投影光学系とを備えた露光装置の製造方法において、前記露光装置が製造される第１環境条件と前記露光装置が使用される第２環境条件との差異に基づいて、第２環境条件のもとで前記投影光学系の光学性能が最適となるように前記投影光学系に関する

調整量を算出する調整量算出工程と、前記調整量算出工程にて得られた前記投影光学系に関する調整量に基づいて前記投影光学系を調整する光学調整工程と、前記光源から出力される光の基準波長を該基準波長とは異なる検査用の光の波長に調整する波長調整工程と、前記波長調整工程によって調整された波長を持つ検査用の光を用いて前記調整工程によって調整された前記投影光学系の光学特性を前記第１環境条件のもとで検査する検査工程とを有する露光装置の製造方法を提供するものである。

【００１７】請求項１１に係る発明では、請求項１０の発明に基づき、前記波長調整工程は、前記第１環境条件と前記第２環境条件との差異に基づき、前記投影光学系の光学性能を検査するための検査用の光の波長を求める波長算出工程とを含む露光装置の製造方法を提供するものである。請求項１２に係る発明では、所定のパターンが形成されたマスクを照明するために、所定の基準波長を持つ光を出力する光源と、前記マスクのパターンの像を感光性基板に投影する投影光学系とを備えた露光装置の製造方法において、第１環境条件のもとで前記投影光学系を調整する第１調整工程と、前記第１調整工程によって調整された前記投影光学系の光学性能を前記光源から出力される前記基準波長を持つ光を用いて前記第１環境条件のもとで検査する第１検査工程と、前記第１調整工程及び前記第１検査工程が実行される第１環境条件と前記露光装置が使用される第２環境条件との差異に基づいて、第２環境条件のもとで前記投影光学系の光学性能が最適となるように前記投影光学系に関する調整量を算出する調整量算出工程と、前記調整量算出工程にて得られた前記投影光学系に関する調整量に基づいて前記投影光学系を調整する第２調整工程と、前記光源から出力される光の基準波長を第２検査用の光の波長に調整する波長調整工程と、前記波長調整工程によって調整された波長を持つ前記第２検査用の光を用いて前記２調整工程によって調整された前記投影光学系の光学特性を前記第１環境条件のもとで検査する第２検査工程とを有する露光装置の製造方法を提供するものである。

【００１８】請求項１３に係る発明では、請求項１２の発明に基づいて、前記波長調整工程は、前記第１環境条件と前記第２環境条件との差異に基づき、前記投影光学系の光学性能を再検査するための前記第２検査用の光の波長を求める波長算出工程を含む露光装置の製造方法を提供するものである。請求項１４に係る発明では、請求項１０乃至請求項１３のいずれか１項の発明に基づき、前記露光装置が使用される前記第２環境条件のもとに設置される迄に、前記光源から出力される光の波長を前記基準波長に設定する基準波長設定工程をさらに有する露光装置の製造方法を提供するものである。

【００１９】請求項１５に係る発明では、請求項１４に記載の露光装置の製造方法によって製造された露光装置を提供する工程と、前記光源からの基準波長によって前記マスクを照明する照明工程と、前記投影光学系を介して前記マスクのパターン像を前記感光性基板に投影する投影工程とを含む露光方法を提供するものである。

【００２０】

【発明の実施の形態】環境変化の１つの要因として、標高差による気圧の変化が挙げられる。例えば、一般的に標高が高くなると、それに伴い気圧が下がる。そして、標高、気圧及び空気の温度との関係は以下の（１）式に示す関係で表現できる。

$$(1)\qquad h = 18400(\log B_0 - \log B)(1 + \alpha T)$$

ここで、ｈは標高（ｍ）、B_0 は低地での気圧（ｈＰａ）、Ｂは高地での気圧（ｈＰａ）、αは空気膨張係数（$\alpha = 0.0036728$）、Ｔは標高ｈでの空気の温度（°Ｃ）である。

【００２１】次に、標準空気（１５°Ｃ、1.01325×10^5 Ｐａ）中での光の波長λ（真空中では０．２～１．３５μｍ、）と標準空気の屈折率 n_S との関係は以下の（２）式に示す関係で与えられる。

$$(2)\qquad (n_S - 1)\times10^8 = 6432.8 + 2949810/(146 - \lambda^{-2}) + 25540/(41 - \lambda^{-2})$$

また、気圧Ｐ（Ｐａ）、空気の温度Ｔ（°Ｃ）及び空気の屈折率 n_{air} の関係は以下の（３）式に示す関係で与えられる。

$$(3)\qquad n_{air} = 1 + [(n_S - 1)\ P\ (1 + 7.501\times10^{-3} P\beta_T)(1 + 15\alpha)] / [1.013\times10^5(1 + 760\ \beta_{15})(1 + \alpha T)]$$

ここで、β_T 及び β_{15} にはそれぞれ $\beta_T = (1.049 - 0.0157T)\times10^{-6}$、$\beta_{15} = 0.8135\times10^{-6}$ の関係が成立する。

【００２２】そして、上記（１）乃至（３）式より、低地と高地での空気の屈折率を求めることができる。また、ここで、低地における光学系を構成するレンズ等の屈折光学素子の屈折を考える。今、低地での空気の屈折率を n_L、光学系のレンズ等の屈折光学素子の第１波長 λ_1 に対する絶対屈折率を n_{abs1}、光学系のレンズ等の屈折光学素子の屈折面への第１波長 λ_1 の光線の入射角を θ_1、光学系のレンズ等の屈折光学素子の屈折面からの第１波長 λ_1 の光線の射出角を θ_1' とするとき、屈折光学素子の屈折面では、屈折の法則（スネルの法則）から、以下の（４）式の関係が成立する。

$$(4)\qquad n_{airL}\times\sin\theta_1 = n_{abs1}\times\sin\theta_1'$$

一方、次に、高地における光学系を構成するレンズ等の屈折光学素子の屈折を考える。今、高地での空気の屈折率を n_H、光学系のレンズ等の屈折光学素子の屈折面への第１波長 λ_1 の光線の入射角を θ_2、光学系のレンズ等の屈折光学素子の屈折面からの第１波長 λ_1 の光線の射出角を θ_2' とするとき、屈折光学素子の屈折面では、

屈折の法則（スネルの法則）から、以下の（５）式の関係が成立する。

（５）　$n_{airH} \times \sin\ \theta_2 = n_{abs1} \times \sin\ \theta_2'$

ここで、$\theta_1 = \theta_2$、$\theta_1' = \theta_2'$ の場合には、低地と高地での屈折角が同じであるため、光学系にて発生する収差は同じである。しかしながら、$n_{airL} \neq n_{airH}$ である限り、低地と高地での収差は同じにならない。

【００２３】このため、低地での屈折角と高地での屈折角とを同じくするためには、光学系のレンズ等の屈折光学素子の屈折面への第２波長 λ_2 の光線の入射角を θ_2、光学系のレンズ等の屈折光学素子の屈折面からの第２波長 λ_2 の光線の射出角を θ_2'、光学系のレンズ等の屈折光学素子の第２波長 λ_2 に対する絶対屈折率を n_{abs2} とするとき、以下の（６）式の関係を満足すれば良い。

（６）　$n_{airL} \times \sin\ \theta_2 = n_{abs2} \times \sin\ \theta_2'$

従って、上記（５）式及び上記（６）式の関係から以下の（７）式が導出できる。

（７）　$n_{abs2} = n_{airL} \times n_{abs1} / n_{airH}$

以上のように、光学系を低地に置いた状態で、光源から供給される光の第１波長 λ_1 を、光学系を構成する屈折光学素子の絶対屈折率が上記（７）式に相当する第２波長に変化させることによって、露光装置等の光学装置全体を気圧可変チャンバー等の大掛かりな装置を用いることなく、光学系の光学性能を例えば高地に置いた状態と同じ条件で調整及び評価をすることができる。

【００２４】なお、この場合、光学系の光学性能をより正確に調整及び評価するためには、光学系を構成する全ての屈折光学素子が同じ分散、即ち同一種類の硝材から構成されていることが望ましい。さて、次に、図１及び図２を参照しながら本発明の実施の形態について説明する。

【００２５】図１は本発明の実施の形態による露光装置の概略的な構成図である。図１に示すように、光源１は、例えば、248nm の波長を持つレーザ光を発振するＫｒＦエキシマレーザや193nm の波長を持つレーザ光を発振するＡｒＦエキシマレーザ等のレーザ光源で構成されている。光源１から供給された光は照明光学系１２を介して所定の回路パターンが形成されたマスクを均一に照明する。

【００２６】なお、図１では図示していないが、照明光学系１２は、光源１からの光束径（又は光束の断面形状）を適切な大きさの光束径（又は光束の断面形状）に整形するビーム整形光学系、そのビーム整形光学系からの光を受けて多数の光源を形成するオプティカルインテグレータ系（１つまたは複数のフライアイレンズ又は内面反射型のロッド状の棒状光学部材）、そのオプティカルインテグレータ系からの複数の光源からの光をそれぞれ集光して、マスク１３を重畳的に照明するコンデンサー光学系とを有している。

【００２７】さて、照明光学系１２によって照明されたマスク１３のパターン像は、投影光学系１４によって感光性基板（ウエハ等）１４に転写（露光）される。ここで、投影光学系１４は、多数の屈折系光学素子で構成される屈折型投影光学系、あるいは多数の屈折系光学素子と少なくとも１枚以上の反射型光学素子（凹面鏡や凸面鏡等）との組合せで構成される反射屈折型投影光学系で構成されている。

【００２８】図２は図１に示した露光装置の光源１１としてのエキシマレーザ光源の構造を示している。図２に示すように、エキシマレーザ光源は、共振器と放電電極等を含むエキシマレーザ発振部（レーザチャンバー）２３、プリズム２２と反射型回折格子２１とを含みエキシマレーザ発振部２３から出力されるレーザ光の波長を狭帯化する波長狭帯部とを有している。そして、エキシマレーザ光源から射出される狭帯化されたレーザ光は、図１に示す照明光学系１２へ導かれる。

【００２９】また、エキシマレーザ光源から出力されるレーザ光の射出側には、エキシマレーザ光源から出力されるレーザ光の１部を分岐させる光分割部材２５が配置され、光分割部材２５の反射方向には、光分割部材２５を反射したレーザ光の波長を監視する波長検出装置としての波長モニター２４が設けられている。この波長モニター２４はエタロン等の光学素子を含み、このエタロン等の光学素子を用いてレーザ光の波長が測定される。さらに、この波長モニター２４にて計測されたレーザ光の出力波長が適切でない場合、波長モニター２４にて計測された情報に基づいて、波長狭帯部中のプリズム２２や反射型回折格子２１の傾き（角度）を算出する（波長狭帯部の調整量を算出する）調整量算出部２６と、この調整量算出部からの情報に基づいて、波長狭帯部中のプリズム２２や反射型回折格子２１を適切な傾き（角度）に設定する駆動部２７がそれぞれ設けられている。

【００３０】なお、設定すべき波長等の入力情報は、コンソール等の入力部２８を介して調整量算出部２６に入力され、調整量算出部２６は、波長モニター２４からの計測情報と入力部２８からの入力情報とに基づいて波長調整手段（プリズム２２や反射型回折格子２１）に関する波長調整量を算出する。以上の図２に示す出力波長調整機構を備えたエキシマレーザ光源を光源として用いることによって、適切な波長の光を照明光学系１２及び投影光学系１４へ導くことができる。

【００３１】以上の図１及び図２に示した露光装置によって本発明による投影光学系１４の評価方法について図３を参照しながら説明する。

〔ステップ１〕低地において、多数の光学部材（レンズ、レンズ保持部材等）で組み上げられた投影光学系１４を調整する。つまり、このステップ１では、投影光学系１３を構成する光学部材の製造誤差や組立て誤差等により発生する収差を補正するために、投影光学系１４を

構成する光学部材間の間隔（例えば、レンズ間の間隔）を変化させたり、あるいは投影光学系１４を構成する光学部材を傾斜、又は光軸と直交する方向に変位させる等の手法により投影光学系１４を調整する。

〔ステップ２〕上記ステップ１において調整された投影光学系１４が低地の環境条件において所定の光学性能（結像性能）を満たしているか否かを確認するために、ステップ２では投影光学系１４の光学性能を検査（又は評価）する。投影光学系１４の光学性能は、例えば、試し露光の手法によって評価される。試し露光とは、図１に示すように、投影光学系１４を一旦露光装置本体に取りつけて、投影光学系１４の物体面に所定のテストパターンが形成されたテストマスク１３を設定し、投影光学系１４の像面に感光性基板（レジストが塗布されたウエハ等）１５を設定する。そして、図１に示すように、光源１からの光を照明光学系１２を介してテストマスク１３を照明し、投影光学系１４を介してテストマスク１３のテストパターン像を感光性基板１５に転写する。その後、感光性基板１５上に転写されたテストパターン像を電子顕微鏡等の観察装置を用いて観察や計測することにより、投影光学系１４の光学性能を評価することができる。

【００３２】なお、投影光学系１４の光学性能を検査（評価）する手法としては、試し露光の手法に限らない。例えば、投影光学系１４の物体面にテストマスクを設定し、投影光学系１４の像面もしくはそれと共役な位置にテストマスクの像を光電検出する検出系とその検出系からの出力信号に対し所定の信号処理を行う処理装置とを配置し、露光用の波長を持つ光を上記テストマスクに照明する。これにより、その処理装置からの処理情報に基づいて投影光学系１４の光学性能を光電的に検出・評価することができる。さらには、投影光学系１４の光学性能は、露光用の波長を持つ光を用いる干渉計システムによっても検査（評価）することも可能である。

【００３３】ここで、以上に述べた手法によって投影光学系１４の光学性能を評価した結果、もし、投影光学系１４の光学性能が所定の光学性能を満たしていない場合には再び上記ステップ１に戻って、再度投影光学系１４の調整が実行される。また、もし、投影光学系１４の光学性能が所定の光学性能を満たしている場合には、次のステップ３へ移行する。

〔ステップ３〕ステップ３では、まず、第１のサブステップにおいて、低地と高地との環境条件の差異の１つとしての気圧の差異に基づいて、低地での空気の屈折率、高地での空気の屈折率について算出する。次に、第２のサブステップにおいて、上記ステップ２を経た投影光学系１４の調整後のレンズデータ、及び第１のサブステップにて求められた低地での空気の屈折率、高地での空気の屈折率及び波長変更量に基づいて、投影光学系１４の高地向けのオフセット量を算出する。以下において、各サブステップについて１例を挙げながら具体的に説明する。

（第１のサブステップ）第１のサブステップにおいては、低地と高地との気圧差に基づき、低地での空気の屈折率、高地での空気の屈折率及び評価用または露光用の光源から出力される光の波長変更量について算出する。

【００３４】まず、露光装置の投影光学系１４の調整、評価を行う地点（低地）での標高を海抜５０ｍ、露光装置を設置してこれを実際に使用する地点（高地）での標高を海抜１０００ｍ、低地及び高地での空気の温度（露光装置の設定温度）を２３°Ｃ、露光装置の光源であるエキシマレーザ光源から発振される光の波長λを０．２４８４μｍ、標高０ｍ（海抜０ｍ）での大気圧を１気圧（１０１３．２５ｈＰａ）、標高５０ｍ（低地）の地点での大気圧をB_Lとすると、標高５０ｍ（低地）の地点での大気圧B_Lは、前述した（１）式から以下に示す（８）式のようになる。

（８）　$B_L = 1007.4207\,\mathrm{hPa}$

また、標高１０００ｍ（高地）の地点での大気圧をB_Hとすると、標高１０００ｍ（高地）の地点での大気圧B_Hは、前述した（１）式から以下に示す（９）式のようになる。

（９）　$B_H = 902.8221\,\mathrm{hPa}$

また、標準空気（温度：１５°Ｃ、気圧：１．０１３２５×１０⁵Ｐａ＝１０１３．２５ｈＰａ）に対する波長が０．２４８４μｍの光の屈折率は、上記（２）式より以下に示す（１０）式のようになる。

（１０）　$n_S = 1.0003019$

従って、標高５０ｍの地点（低地）での波長が０．２４８４μｍの光に対する２３°Ｃの空気の屈折率n_{airL}は、上記（３）式に上記（８）式及び（１０）式の値を代入することにより、以下に示す（１１）式のようになる。

（１１）　$n_{airL} = 1.0002920$

一方、海抜１０００ｍでの波長が０．２４８４μｍの光に対する２３°Ｃの空気の屈折率n_{airH}は、上記（３）式に上記（９）式及び（１０）式の値を代入することにより、以下に示す（１２）式のようになる。

（１２）　$n_{airH} = 1.0002617$

（第２のサブステップ）以上の第１のサブステップにて得られた低地の環境条件のもとでの空気の屈折率（$n_{airL} = 1.0002920$）、高地の環境条件のもとでの空気の屈折率（$n_{airH} = 1.0002617$）に基づいて、図１に示す投影光学系１４を構成する複数の光学素子の少なくとも１つに関して高地での結像性能が最適となるように高地向けの調整量又は調整値を求める。

【００３５】ここで、一例として、図４に示す投影光学系１４のレンズデータを表１に掲げる。以下の表１に示されるレンズデータは、上記ステップ１の調整工程及び上記ステップ２の低地の環境条件のもとでの検査工程

（評価工程）を経て低地での光学性能が十分に引き出された状態でのものである。表１において、Ｂは投影光学系の投影倍率、ＮＡは投影光学系の像側（ウエハ側）での開口数、Ｌは物体面Ｒ（レチクル１３）から像面Ｗ（ウエハ１５）までの距離（物像間距離）、左端の数字は物体（レチクル１３）側からのレンズ面の順序、ｒはレンズ面の曲率半径、ｄは各レンズ面の間隔、左端の記号は図３に示すレンズの番号を示している。但し、表１に示す全てのレンズは合成石英で構成され、波長λが０．２４８４μｍの光に対する合成石英の屈折率は、１．５０８３９００である。

〔表１〕

Ｂ＝１／５、ＮＡ＝０．５５、Ｌ＝１２００

	r	d	
0	∞	104.71662	R
1	955.26796	23.00000	L1
2	−675.53148	20.81278	(空気)
3	788.04209	24.00000	L2
4	−320.77870	7.92536	(空気)
5	−261.99847	20.00000	L3
6	−613.40707	1.04750	(空気)
7	343.77433	27.00000	L4
8	−614.74297	0.97572	(空気)
9	220.40014	24.00000	L5
10	111.87626	27.04713	(空気)
11	230.00000	23.00000	L6
12	−410.00000	1.10686	(空気)
13	−2449.05000	17.00000	L7
14	118.87129	18.76700	(空気)
15	−632.77988	12.90000	L8
16	143.15226	26.88549	(空気)
17	−108.88557	15.00000	L9
18	595.22400	52.22565	(空気)
19	1526.21000	35.00000	L10
20	−168.52598	14.91509	(空気)
21	−120.87196	22.80000	L11
22	−188.10351	2.79782	(空気)
23	−3191.22000	27.00000	L12
24	−296.62706	2.87255	(空気)
25	697.45117	28.00000	L13
26	−669.27158	2.49780	(空気)
27	358.82454	27.00000	L14
28	−2986.21000	1.64701	(空気)
29	223.50971	31.00000	L15
30	−1510.16000	8.60527	(空気)
31	−3596.81000	21.00000	L16
32	141.11696	9.76890	(空気)
33	194.35300	17.00000	L17
34	157.66411	31.54706	(空気)
35	−209.96142	15.90000	L18
36	307.10883	56.68624	(空気)
37	−175.13115	18.00000	L19
38	−1162.95000	6.28784	(空気)
39	−505.38166	23.00000	L20
40	−213.39177	1.14438	(空気)
41	3114.45000	23.00000	L21

42	-339.03822	2.92283	(空気)
43	460.54759	40.00000	L22
44	-326.27369	9.43498	(空気)
45	-231.89968	27.00000	L23
46	-372.57441	1.10071	(空気)
47	390.03678	28.00000	L24
48	-1994.66000	4.83032	(空気)
49	182.18377	29.00000	L25
50	525.45378	3.29194	(空気)
51	138.67730	39.90000	L26
52	312.43609	9.82671	(空気)
53	511.48346	23.00000	L27
54	81.45867	7.04896	(空気)
55	93.64185	34.00000	L28
56	934.34560	2.00000	(空気)
57	826.70065	35.00000	L29
58	1680.21000	28.76320	(空気)
59	∞		W

図５及び図６には図４に示した投影光学系の収差図を示している。図５における（ａ）及び（ｂ）は、上記表１に示したレンズデータに基づいて得られる球面収差の様子を示している。図５において、（ａ）は標高５０ｍの地点（低地）での波長λ＝０．２４８４μｍ（第１波長）に対する球面収差の様子を示す図、（ｂ）は標高１０００ｍの地点（高地）での波長λ＝０．２４８４μｍ（第１波長）に対する球面収差の様子を示す図である。但し、図５（ａ）及び図６（ｂ）に示す球面収差図は表１に示されるレンズデータの空気の屈折率を n_{airL}＝１．０００２９２０（上記（１１）式にて示される標高５０ｍの低地での空気の屈折率）とした場合のものである。

【００３６】また、図６における（ａ）及び（ｂ）は、上記表１に示したレンズデータに基づいて得られる歪曲収差の様子を示している。図６において、（ａ）は標高５０ｍの地点（低地）での波長λ＝０．２４８４μｍ（第１波長）に対する歪曲収差の様子を示す図、（ｂ）は標高１０００ｍの地点（高地）での波長λ＝０．２４８４μｍ（第１波長）に対する歪曲収差の様子を示す図である。但し、図６（ａ）及び図６（ｂ）の歪曲収差図は表１に示されるレンズデータの空気の屈折率を n_{airH}＝１．０００２６１７（上記（１２）式にて示される標高１０００ｍの高地での空気の屈折率）とした場合のものである。

【００３７】以上のように、図５（ａ）及び図６（ａ）に示されるように、表１に示す投影光学系は標高５０ｍの地点（低地）において収差が良好に補正されることが分かる。しかしながら、図５（ｂ）及び図６（ｂ）に示されるように、表１に示す投影光学系は標高１０００ｍの地点（高地）において収差が悪化しており、例えば、球面収差が最大で－５μｍ発生していることがが分かる。

【００３８】このように、大きな球面収差や歪曲収差等の諸収差が発生している状況では、投影光学系の所望の光学性能を発揮させせることはできない。従って、投影光学系において、事前に標高１０００ｍの高地向けのオフセットを持たせることが必要となる。そこで、第２のサブステップでは、標高１０００ｍの地点（高地）において良好なる光学性能を引き出すために、図４に示す投影光学系を構成する各光学素子（レンズ）の調整量又は調整値を求める。各光学素子（レンズ）の調整量又は調整値は、計算機等の演算装置を用いて表１に示されるレンズデータに基づき光線追跡等の自動設計を行ことにより求められる。このとき、光線追跡等の自動設計される時、表１の空気の屈折率は、上記（１２）式にて示したように、標高１０００ｍの高地での空気の屈折率（n_{airH}＝１．０００２６１７）である。

【００３９】以下の表２において、表１に示されるレンズデータに基づき計算機等の演算装置によって求められた投影光学系を構成する光学素子（レンズ）の高地向けの調整値を示すレンズデータを掲げる。表２に示す例では、標高１０００ｍの地点（高地）において良好なる光学性能を引き出すために、表１に示すレンズＬ２～Ｌ29のレンズ間隔（空気間隔）を僅かに変更して、高地向けの収差オフセットを加えた状態のレンズデータを示している。ここで、表２では、レンズＬ２～Ｌ29のレンズ間隔（空気間隔）の値をレンズの調整値として示している。

〔表２〕
Ｂ＝１／５、ＮＡ＝０．５５、Ｌ＝１２００

	r	d	
0	∞	104.71662	R
1	955.26796	23.00000	L1
2	−675.53148	20.81327	(空気)
3	788.04209	24.00000	L2
4	−320.77870	7.92688	(空気)
5	−261.99847	20.00000	L3
6	−613.40707	1.05238	(空気)
7	343.77433	27.00000	L4
8	−614.74297	0.98439	(空気)
9	220.40014	24.00000	L5
10	111.87626	27.05197	(空気)
11	230.00000	23.00000	L6
12	−410.00000	1.11599	(空気)
13	−2449.05000	17.00000	L7
14	118.87129	18.76715	(空気)
15	−632.77988	12.90000	L8
16	143.15226	26.88300	(空気)
17	−108.88557	15.00000	L9
18	595.22400	52.22598	(空気)
19	1526.21000	35.00000	L10
20	−168.52598	14.91713	(空気)
21	−120.87196	22.80000	L11
22	−188.10351	2.79542	(空気)
23	−3191.22000	27.00000	L12
24	−296.62706	2.87454	(空気)
25	697.45117	28.00000	L13
26	−669.27158	2.50251	(空気)
27	358.82454	27.00000	L14
28	−2986.21000	1.65252	(空気)
29	223.50971	31.00000	L15
30	−1510.16000	8.59879	(空気)
31	−3596.81000	21.00000	L16
32	141.11696	9.76690	(空気)
33	194.35300	17.00000	L17
34	157.66411	31.54381	(空気)
35	−209.96142	15.90000	L18
36	307.10883	56.68480	(空気)
37	−175.13115	18.00000	L19
38	−1162.95000	6.27984	(空気)
39	−505.38166	23.00000	L20
40	−213.39177	1.14425	(空気)
41	3114.45000	23.00000	L21
42	−339.03822	2.92562	(空気)
43	460.54759	40.00000	L22
44	−326.27369	9.43390	(空気)
45	−231.89968	27.00000	L23
46	−372.57441	1.10621	(空気)
47	390.03678	28.00000	L24
48	−1994.66000	4.83821	(空気)
49	182.18377	29.00000	L25
50	525.45378	3.29556	(空気)
51	138.67730	39.90000	L26
52	312.43609	9.82752	(空気)
53	511.48346	23.00000	L27
54	81.45867	7.05951	(空気)
55	93.64185	34.00000	L28
56	934.34560	1.99581	(空気)
57	826.70065	35.00000	L29
58	1680.21000	28.74943	(空気)
59	∞		W

図５における（ｃ）及び（ｄ）は、上記表２に示したレンズデータに基づいて得られる球面収差の様子を示している。図５において、（ｃ）は標高１０００ｍの地点（高地）向けの収差オフセットを投影光学系に持たせた場合において、波長λ＝０．２４８４μｍ（第１波長）に対する低地での環境条件のもとでの球面収差の様子を示す図、（ｂ）は標高１０００ｍの地点（高地）向けの収差オフセットを投影光学系に持たせた場合において、波長λ＝０．２４８３１８μｍ（第２波長）に対する高地での環境条件のもとでの球面収差の様子を示す図である。但し、図５（ｃ）に示す球面収差図は表２に示されるレンズデータの空気の屈折率をn_{airL}＝１．０００２９２０（標高５０ｍの低地での空気の屈折率）とした場合のものであり、図５（ｄ）に示す球面収差図は表２に示されるレンズデータの空気の屈折率をn_{airH}＝１．０００２６１７（標高１０００ｍの高地での空気の屈折率）とした場合のものである。

【００４０】また、図６における（ｃ）及び（ｄ）は、上記表２に示したレンズデータに基づいて得られる球面収差の様子を示している。図６において、（ｃ）は標高１０００ｍの地点（高地）向けの収差オフセットを投影光学系に持たせた場合において、波長λ＝０．２４８４μｍ（第１波長）に対する低地での環境条件のもとでの歪曲収差の様子を示す図、（ｂ）は標高１０００ｍの地点（高地）向けの収差オフセットを投影光学系に持たせた場合において、波長λ＝０．２４８３１８μｍ（第２波長）に対する高地での環境条件のもとでの歪曲収差の様子を示す図である。但し、図６（ｃ）に示す歪曲収差図は表２に示されるレンズデータの空気の屈折率をn_{airL}＝１．０００２９２０（標高５０ｍの低地での空気の屈折率）とした場合のものであり、図５（ｄ）に示す歪曲収差図は表２に示されるレンズデータの空気の屈折

率をn_{airH}＝１．０００２６１７（標高１０００ｍの高地での空気の屈折率）とした場合のものである。

【００４１】なお、図５（ｄ）に示す球面収差図及び図６（ｄ）に示す歪曲収差図は、後述するが、表２に示されるレンズデータの空気の屈折率をn_{airL}＝１．０００２９２０（上記（１２）式にて示される標高５０ｍの低地での空気の屈折率）とし、光の波長をλ＝０．２４８３１８μｍ（第２波長）に変更した場合での球面収差曲線と歪曲収差曲線に合致する。

【００４２】以上の表２に示すように投影光学系の収差オフセット（例えば、L2 ～L29のレンズ間隔（空気間隔））の値が求められると、次のステップ４へ移行する。

〔ステップ４〕ステップ４では、上記ステップ３の第２サブステップにて求められた投影光学系の収差オフセット（例えば、表２に示されるL2 ～L29のレンズ間隔（空気間隔））の値に基づいて、投影光学系を構成する各レンズの設定位置等を再調整する。そして、この再調整の工程が完了すると、その差異調整された投影光学系は図１に示す露光装置本体に取りつけられ、その後、次のステップ５の出力波長の調整工程へ移行する。

〔ステップ５〕ステップ５では、投影光学系の検査（評価）に際して、低地での環境条件のもとで高地での環境条件を疑似的に再現するために、まず、投影光学系１４を検査（評価）するための露光用の光源１１から供給される検査用の光の波長（第１波長）を所定の波長（第２波長）に設定及び調整する。

【００４３】ステップ５では、光源１１から供給される光の波長を調整するに先立って、まず、設定波長又は調整波長としての第２波長（第２波長とは異なる波長）を算出する。つまり、ステップ５では、光源１１から供給される検査用の光の波長の調整量（又は検査用の光の波長の値）を算出する第１サブステップと、光源１１から供給される検査用の光の波長を調整（又は検査用の光の波長を所定の第２波長に設定）する第２サブステップとを有している。

【００４４】ここで、表１及び表２に示した図４の投影光学系１４に基づいて、第５ステップの具体例を説明する。

（第１サブステップ）表１及び表２に示したように、図４の投影光学系１４を構成する屈折性光学部材として、例えば、表１及び表２に示されるように合成石英が用いられている。

【００４５】今、０．２４８４μｍ（第１波長）の光に対する合成石英の相対屈折率n_{rel}が１．５０８３９００であるものとすると、その合成石英の絶対屈折率n_{abs1}は、上記（７）式、（１１）式及び（１２）式の関係から以下の（１３）式のようになる。

（１３）　$n_{abs1}=n_{rel}\times n_{airL}=1.5088305$

さらに、第２波長の光に対する合成石英の絶対屈折率n_{abs2}は、上記（７）式に上記（１１）式～（１３）式の値を代入すると、以下の（１４）式のようになる。

（１４）　$n_{abs2}=n_{airL}\times n_{abs1}/n_{airH}=1.5088762$

また、波長がλ＝０．２４８４μｍ付近での合成石英の分散を以下の（１５）式の関係にあるものとする。

（１５）　$\Delta n/\Delta\lambda=-56\times10^{-2}\ (\mu m^{-1})$

すると、$\Delta n=n_{abs2}-n_{abs1}$であるため、光源の波長の変更量Δλは、上記（１３）式～（１５）式の関係から約－８．２×１０$^{-5}$μｍとなる。

【００４６】従って、光源の波長を０．２４８４μｍ（第１波長）から０．２４８３１８μｍ（第２波長）に変更することにより、標高が５０ｍの地点において標高が１０００ｍに相当する大気圧の環境下で投影光学系１４の光学性能の評価が可能となる。

（第２サブステップ）ステップ５の第２サブステップでは、算出された波長変化量（Δλ＝－８．２×１０$^{-5}$μｍ）に基づいて、図１に示す光源１１の出力波長がλ＝０．２４８３１８μｍ（第２波長）となるように光源１１の出力波長を調整する。

【００４７】つまり、図２に示すように、ステップ５の第１サブステップにて求められた設定波長としての第２波長（λ＝０．２４８３１８μｍ）に関する情報をコンソール等の入力部２８を介して調整量算出部２６に入力する。そして、調整量算出部２６は、波長モニター２４からの計測情報と入力部２８からの入力情報とに基づいて波長調整手段（プリズム２２や反射型回折格子２１）に関する波長調整量を算出する。その後、調整量算出部２６は、駆動部２７を介して波長調整手段（プリズム２２や反射型回折格子２１）を駆動させる。これにより、最終的にエキシマレーザ発振部２３（光源１）から発振される光の出力波長が第２波長（λ＝０．２４８３１８μｍ）となるように調整される。このステップ５での出力波長の調整工程が完了すると、次のステップ６の検査工程（評価工程）へ移行する。

〔ステップ６〕ステップ６では、上記ステップ４の再調整によって高地向けの収差オフセットが付与された投影光学系１４が第２波長（λ＝０．２４８３１８μｍ）のもとで所定の光学性能を満たしているか否かを確認するために、投影光学系１４の光学性能を上記ステップ２と同様な手法によって検査（評価）する。投影光学系１４の光学性能は、例えば、試し露光の手法によって評価される。そして、例えば、表２に示すように調整された投影光学系１４に関して球面収差が図５（ｄ）に示すように補正され、投影光学系１４の歪曲収差が図６（ｄ）に示すように補正されいるか否かを検査（評価）する。

【００４８】なお、図５（ｄ）及び図６（ｄ）に示す収差図は、高地での環境条件（空気の屈折率n_{airH}が１．

０００２６１７）のもとでの第１波長（λ＝０．２４８４μｍ）に対する球面収差及び歪曲収差の曲線を示しているが、高地向けの収差オフセットを付与された投影光学系１４の光学性能（結像性能）が良好であれば、ステップ６において検査される投影光学系１４の球面収差及び歪曲収差は、図５（ｄ）及び図６（ｄ）に示す収差曲線と合致する。

【００４９】ここで、投影光学系１４の光学性能を評価した結果、もし、投影光学系１４の光学性能が所定の光学性能を満たしていない場合には以下のステップ７の再調整工程へ移行して、再度投影光学系１４の調整が実行される。また、もし、投影光学系１４の光学性能が所定の光学性能を満たしている場合には、以下のステップ６の基準波長への波長再設定工程へ移行する。

〔ステップ７〕ステップ７では、以上のステップ６において投影光学系１４の光学性能が所定の光学性能を満たしていないと判断された時に、上記ステップ２と同じ手法によって多数の光学部材（レンズ、レンズ保持部材等）で組み上げられた投影光学系１４を再調整する。つまり、このステップ７では、高地向けの収差オフセットが付与された投影光学系１４の性能を十分に引き出すために、投影光学系１３を構成する光学部材間の間隔（例えば、レンズ間の間隔）を変化させたり、あるいは投影光学系１４を構成する光学部材を傾斜、又は光軸と直交する方向に変位させる等の手法により投影光学系１４を再調整する。このステップ７の再調整工程が完了すると、再び上記ステップ６へ戻り、投影光学系１４の光学性能が再検査（再評価）される。

〔ステップ８〕以上のステップ６において投影光学系１４の光学性能が所定の光学性能を満たしていないと判断された後に、ステップ８では、露光用光源から出力される波長を高地において実際に使用される露光波長（基準波長）に設定し直す。

【００５０】ここで、以上のステップ５及び６において、投影光学系１４が図１に示す露光装置に取りつけられた場合に、ステップ８では露光装置の光源１を実際の使用状態の基準波長（第１波長）に戻す。露光装置の光源１を実際の使用状態に戻す手法は、まず、図２に示すように、設定波長（基準波長）としての第１波長（λ＝０．２４８４μｍ）に関する情報をコンソール等の入力部２８を介して調整量算出部２６に入力する。そして、調整量算出部２６は、波長モニター２４からの計測情報と入力部２８からの入力情報とに基づいて波長調整手段（プリズム２２や反射型回折格子２１）に関する波長調整量を算出する。その後、調整量算出部２６は、駆動部２７を介して波長調整手段（プリズム２２や反射型回折格子２１）を駆動させる。これにより、最終的にエキシマレーザ発振部２３（光源１）から発振される光の出力波長が第１波長（λ＝０．２４８４μｍ）となるように調整される。

【００５１】以上のように、ステップ１～８を経ることによって露光装置は完成する。このため、この完成した露光装置を例えば高地へ移送及び設置したとしても露光装置の投影光学系１４を調整及び評価した低地の環境下での性能が高地の環境下においても再現することができる。また、ステップ８の工程は露光装置が実際に設置及び使用される場所（例えば、高地）において実行しても良い。この場合、ステップ７とステップ８との間では、露光装置の性能を損なうことなくしかも露光装置の高地への輸送を容易にするために、露光装置を各ユニット（光源１１、照明光学系１２、投影光学系１４等）毎に一旦分解し、高地において露光装置を組み立てるようにすることが望ましい。

【００５２】以上のステップ１～８を経た露光装置をそのまま高地へ移送及び設置（あるいはステップ１～８を経た露光装置を各ユニット毎に一旦分解した上で高地へ移送し、高地において露光装置を組立て設置）する。その後、図１に示す露光装置によって露光工程を実行することによって良好なる半導体デバイスを高地においても製造することができる。この時の露光工程は、図１に示すように、まず、不図示のマスクステージ上に露光用マスク１３を載置して投影光学系１４の物体面に露光用マスク１３を設定すると共に、不図示の基板ステージ上に感光性基板（ウエハ等）を載置して投影光学系１４の像面に感光性基板１５を設定する。次に、光源１からの光を照明光学系１２を介して露光用マスク１３を照明し、投影光学系１４を介して露光用マスク１３の回路パターン像を感光性基板１５に投影する。これによって、高地の環境下においても良好なるマスク１３のパターン像を感光性基板１５に転写することができる。よって、高地の環境下においても良好なる半導体デバイスを製造することができる。

【００５３】ところで、以上においては、投影光学系の光学性能を検査又は評価するに際して、図１に示す露光本体に設けられている露光用の光源１１自身から出力される光を用いた例を図３を参照しながら説明した。しかしながら、本発明は、図１及び図２に示す露光装置と同じ構成を持つ検査専用の検査装置を用いて投影光学系の光学性能を検査又は評価することもできる。この場合での作業手順は図７のフローチャートに示している。

【００５４】図７に示すステップ１１～１６はそれぞれ図３に示すステップ１～６と同じであるため説明を省略する。図７に示すステップ１６での検査装置の光源から出力される検査用の第２波長の光を用いた検査の結果、投影光学系の光学性能が良好であると判断された場合には、ステップ１８に移行する。そして、ステップ１８では、上記ステップ１６を経た投影光学系は、第１波長としての露光波長を出力するように設定された光源を持つ露光装置本体に取りつけられ、露光装置が完成する。

【００５５】このステップ１８では、以上のステップ１

６を経た投影光学系１４及び図１に示す露光装置本体を各ユニット（光源１１、照明光学系１２、投影光学系１４等）毎に分離した状態で高地へ移送し、これらのユニットを高地にて組立て及び設置して、露光装置を完成させても良い。以上のように、以上のステップ１１～１８を経た露光装置を高地へ移送及び設置し、その後、その露光装置によって露光工程を実行することによって良好なる半導体デバイスを高地においても製造することができる。

【００５６】なお、図７に示した例では、１つの検査装置を用いて光源の波長を第１検査用の露光波長（基準波長）としての第１波長から第２検査用の第２波長に変更（変化）させる例を述べたが、本発明は、この手法に限ることはない。例えば、２つの検査装置を用いることによって、図７に示すステップ１６の波長調整工程（波長変化工程）を省略することができる。つまり、第１検査用の露光波長（基準波長）としての第１波長の光を供給する光源を備えた第１検査装置を用いて上記ステップ１２の第１検査工程を実行し、投影光学系が検査又は製造される低地の環境条件と投影光学系が実際に使用される高地と環境条件との差異に基づいて設定された所定の第２波長の第２検査用の光を供給する光源を備えた第２検査装置を用いて上記ステップ１６の第２検査工程を実行する手法を採用しても良い。

【００５７】また、以上の各例では、投影系を含む露光装置の調整及び評価する場所と投影系を含む露光装置を実際に設置及び使用する場所との環境条件の差異として気圧に着目したが、これに限ることはなく、温度差、湿度差等の環境差を考慮しても良いことは言うまでもない。このように、本発明によれば、光学系の調整、評価を行って所望の性能を達成した後、露光装置等の装置が実際に設置及び使用される場所の環境に見合った収差オフセットを与え、次に高地での光学系の光学性能を予め確認するために、露光装置等の装置の光源の波長を変化させることにより、光学系の光学性能を精度良く調整及び評価することが可能となる。

【００５８】また、以上の例では、光学系の調整及び評価を行う地点よりも、露光装置等の装置を実際に設置及び使用する地点での標高が高い例を示したが、本発明は、この逆の場合でも良いことは言うまでもない。なお、以上の特許請求の範囲の請求項１、３、４、６、７、１０、１１、１２、１３等の「第１環境条件と第２環境条件との差異に基づき、」という旨の記載を「第１環境条件と第２環境条件との差異に起因して生ずる光学系（投影光学系）を包囲する気体（媒質）の屈折率の変化（差異）に応じて、」という旨の記載とすることもできる。

【００５９】

【発明の効果】以上のように、本発明によれば、光学系の調整及び検査を行う場所とその光学系が実際に設置又は使用される場所との環境条件の差異があったとしても、その光学系が実際に設置又は使用される場所での環境下と疑似的に同一な環境を、その光学系の光学性能を調整及び検査を行う環境下において簡便に作り出すとこが可能となる。従って、光学系の調整及び検査を行う場所においても、光学系が実際に設置又は使用される場所と同一の光学系の光学性能を精度良く調整及び検査することができる。これによって、良好なる光学性能を有する光学系を製造することができる。

【図面の簡単な説明】

【図１】露光装置の概略的構成を示す図である。

【図２】図１に示す露光装置の光源として使用されるエキシマレーザの構造を示す図である。

【図３】本発明による１つの手法に関する手順を説明するための図である。

【図４】図１に示す露光装置における投影光学系の１例を示すレンズ構成図である。

【図５】図４に示す投影光学系の球面収差の様子を示す図である。

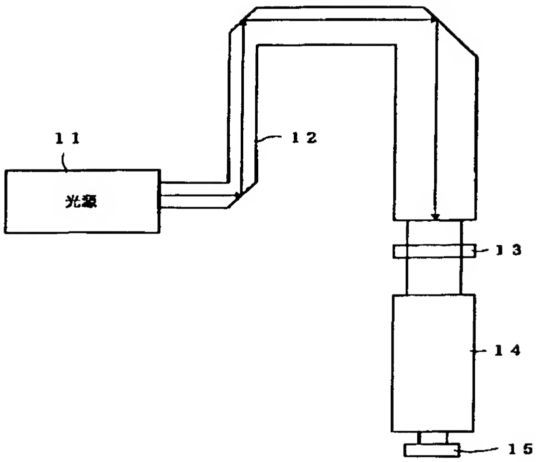
【図６】図４に示す投影光学系の歪曲収差の様子を示す図である。

【図７】本発明による別つの手法に関する手順を説明するための図である。

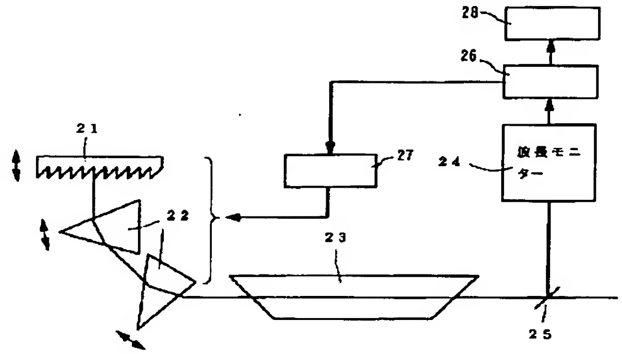
【符号の説明】

１１‥‥‥ 光源
１２‥‥‥ 照明光学系
１３、Ｒ‥‥‥ レチクル
１４‥‥‥ 投影光学系
１５、Ｗ‥‥‥ 基板（ウエハ）
２１‥‥‥ 反射型回折格子
２２‥‥‥ プリズム
２３‥‥‥ エキシマレーザ発振部（レーザチャンバー）
２４‥‥‥ 波長モニター
２５‥‥‥ ハーフミラー
２６‥‥‥ 調整量算出部
２７‥‥‥ 駆動部
２８‥‥‥ 入力部

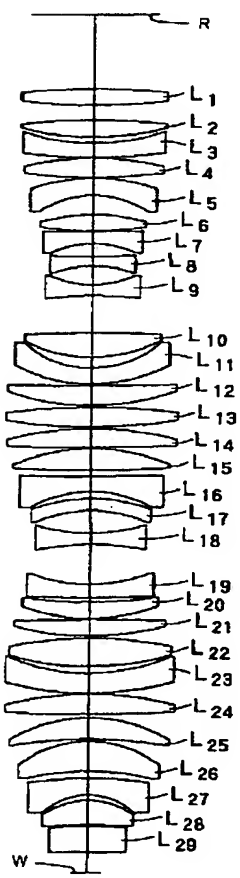
【図１】



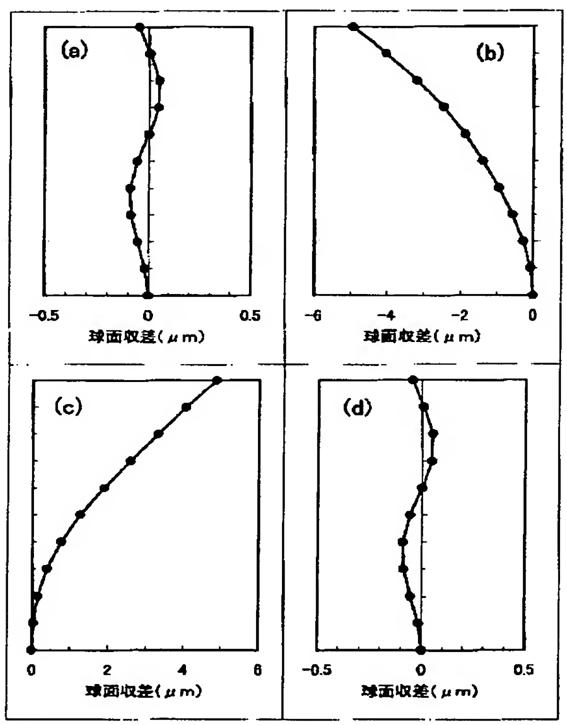
【図２】



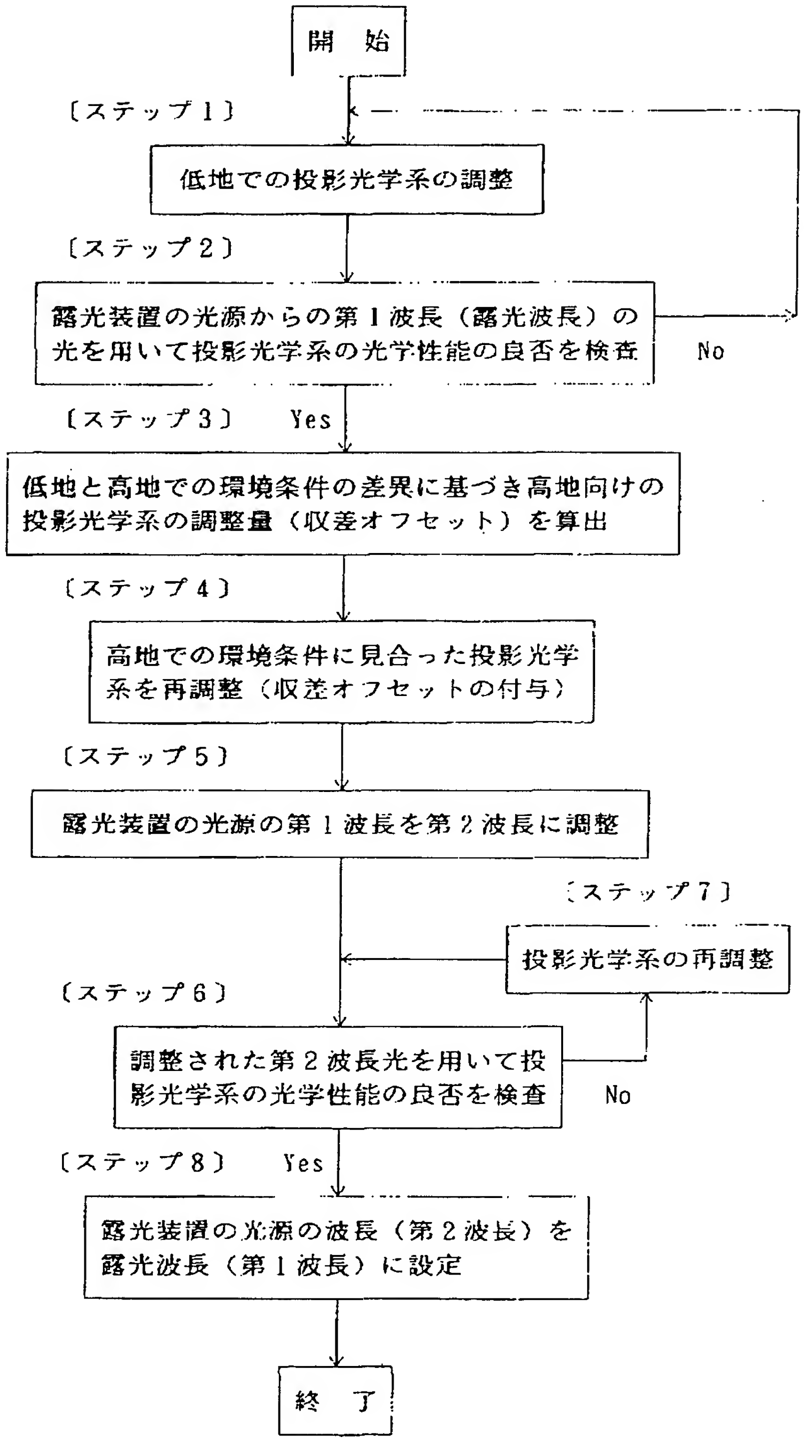
【図４】



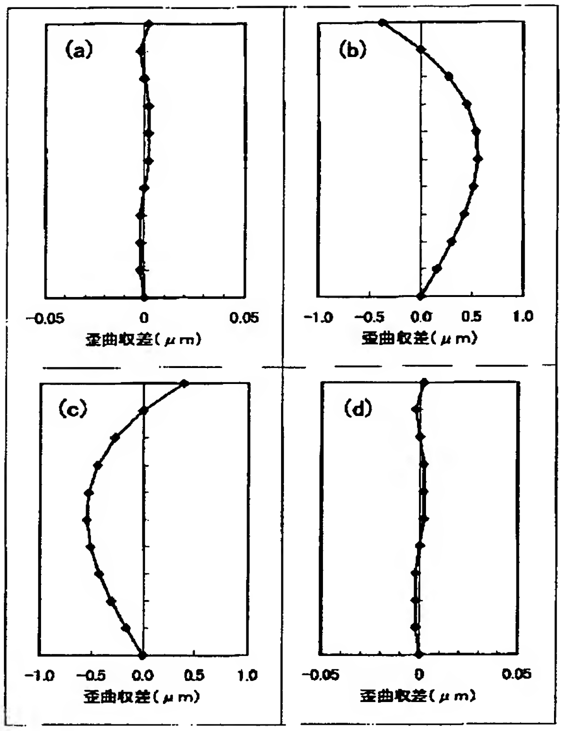
【図５】



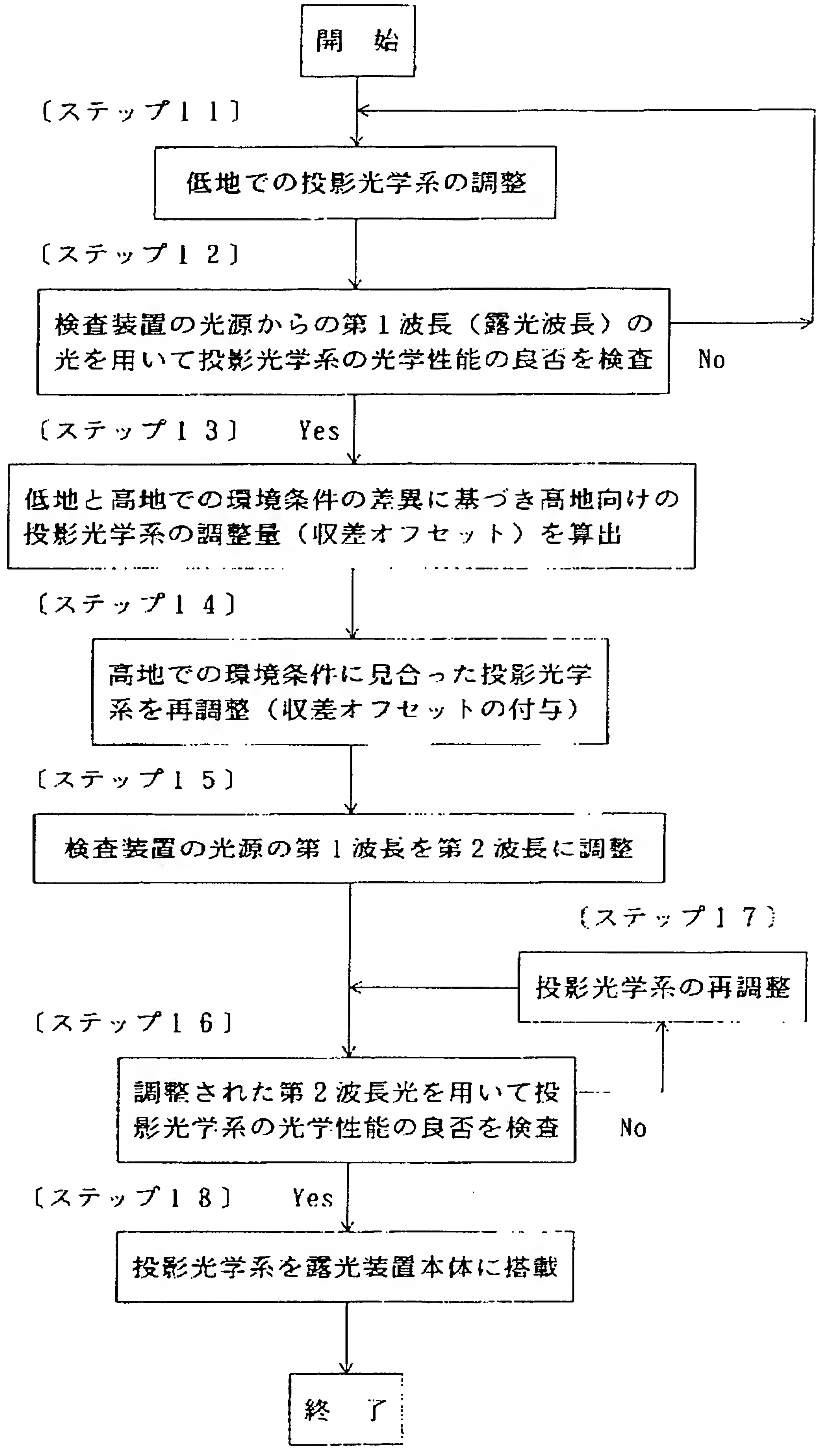
【図３】


開　始
〔ステップ１〕
低地での投影光学系の調整
〔ステップ２〕
露光装置の光源からの第１波長（露光波長）の光を用いて投影光学系の光学性能の良否を検査
No
〔ステップ３〕
Yes
低地と高地での環境条件の差異に基づき高地向けの投影光学系の調整量（収差オフセット）を算出
〔ステップ４〕
高地での環境条件に見合った投影光学系を再調整（収差オフセットの付与）
〔ステップ５〕
露光装置の光源の第１波長を第２波長に調整
〔ステップ７〕
投影光学系の再調整
〔ステップ６〕
調整された第２波長光を用いて投影光学系の光学性能の良否を検査
No
〔ステップ８〕
Yes
露光装置の光源の波長（第２波長）を露光波長（第１波長）に設定
終　了

【図６】


(a)
-0.05
0
0.05
歪曲収差(μm)
(b)
-1.0
-0.5
0.0
0.5
1.0
歪曲収差(μm)
(c)
-1.0
-0.5
0.0
0.5
1.0
歪曲収差(μm)
(d)
-0.05
0
0.05
歪曲収差(μm)

【図７】


開　始
〔ステップ１１〕
低地での投影光学系の調整
〔ステップ１２〕
検査装置の光源からの第１波長（露光波長）の光を用いて投影光学系の光学性能の良否を検査
No
〔ステップ１３〕
Yes
低地と高地での環境条件の差異に基づき高地向けの投影光学系の調整量（収差オフセット）を算出
〔ステップ１４〕
高地での環境条件に見合った投影光学系を再調整（収差オフセットの付与）
〔ステップ１５〕
検査装置の光源の第１波長を第２波長に調整
〔ステップ１７〕
投影光学系の再調整
〔ステップ１６〕
調整された第２波長光を用いて投影光学系の光学性能の良否を検査
No
〔ステップ１８〕
Yes
投影光学系を露光装置本体に搭載
終　了